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VOL. 24 DECEMBER, 1931 No. 6

EXPERIMENTS WITH COPPER CARBONATE, LEAD ARSENATE, AND OTHER COMPOUNDS AGAINST THE MEDITERRANEAN FRUIT FLY IN FLORIDA[1]

By RALPH L. MILLER, *Associate Entomologist*, and O. C. MCBRIDE, *Entomologist*, *Bureau of Entomology, United States Department of Agriculture*

ABSTRACT

Copper carbonate used in a solution of syrup and sugar was found to be almost as toxic to the Mediterranean fruit fly (*Ceratitis capitata* Wied.) as was lead arsenate. Many copper compounds and others were found to be quite toxic.

Toxicity was reduced by low temperature, low concentration, and alkalinity of the insecticide mixture. The kill was slower with flies that had previously fed well on normal food and it was reduced by reducing the area covered by the insecticide. Humidity, light, and pressure affected toxicity very little.

Copper carbonate had little effect on citrus trees or fruit whereas lead arsenate caused many leaves to drop and reduced the anhydrous citric acid.

TOXICITY OF COPPER COMPOUNDS TO FRUIT FLIES.—With the inauguration of the eradication campaign in Florida against the Mediterranean fruit fly (*Ceratitis capitata* Wied.) an insecticide for the adult flies became necessary. Arsenical compounds were by far the most commonly used for this purpose and lead arsenate was, therefore, employed during the early part of the campaign. Since it had been previously demonstrated, however, that arsenic reduces the acid in maturing citrus fruits, experiments were at once begun with other compounds.

[1]The research work on the Mediterranean fruit fly during the eradication campaign was centered at the laboratory of the Bureau of Entomology at Orlando, Fla., and was under the direction of the Division of Subtropical Plant Insects of that Bureau. Several state and federal agencies cooperated in the work, which was largely financed by funds assigned to the Bureau by the Plant Quarantine & Control Administration. Edgar F. Grossman, assigned to the work by the State Experiment Station, carried out some of the earlier toxicity series before O. C. McBride of the Bureau of Entomology took charge of the toxicity work. The studies here reported were initiated when R. L. Miller, at that time an employee of the State Plant Board, was under temporary appointment at the laboratory.

While the insecticide series covered a wide range of compounds, emphasis was placed on the copper salts. Flies in cages made of copper screen had died abnormally young, and analysis after death showed traces of copper. In view of the fact, therefore, that copper compounds had been successfully used on citrus trees in Florida for many years, copper seemed to offer the most promise.

The use of copper compounds as insecticides against the Mediterranean fruit fly, however, is not new. In 1905 Lotriconte[2] used the following formula: commercial sugar 94 parts, honey 2 parts, glycerin 2 parts, copper sulphate 2 parts. In 1912 he modified this formula to sugar 17,500 kg., copper sulphate 1,750 kg., citric acid 100 kg., and water enough to make 100 liters. These mixtures were used not for spraying trees but for killing flies in bait pans or traps.

In 1924 L. J. Newman[3] states that he used bluestone (copper sulphate) with sweetened bait and that the flies could be destroyed with it, but that damage was done to the foliage and fruit.

In 1925 W. B. Gurney[4] reports that when Bordeaux mixture (6–4–50) was applied two months before harvesting, the fruit-fly infestation was reduced from 33 infested fruits in 48 cases on the untreated plots to 7 infested fruits in 51 cases on the treated plots. Mr. Gurney considered the Bordeaux mixture as a deterrent to the fruit fly.

The most substantial support, however, to the use of copper as an insecticide is given by the work of DeLong.[5]

The first and probably most natural conclusion in the case of the fruit fly, was that the flies were not feeding on the copper mixture but were starving. The death rate was quite similar to that produced by starvation. This objection has, however, been set aside by numerous observations, for when flies are introduced into a cage where copper carbonate-syrup-sugar solution is available they immediately begin feeding on the mixture and their abdomens become greatly distended.

[2]D. Jesus Maria Berro Agulera, Agronomo-Director. El Gusano de las Frutas Ceratitis Capitata Wied. 1927. Cuerpo Nacional de Ingerieros Agronomous, Estacion de Pathologia Vegetal de Almeria, Spain.

[3]L. J. Newman. Fruit Fly Description and Control. Bull. 122 Western Australia Dept. of Agr., pp. 41, 1924.

[4]W. B. Gurney. Deterrents for Fruit Flies. Agr. Gaz. New South Wales Dec., 1925, p. 9.

[5](1) D. M. DeLong. Bordeaux Mixture as a Leaf Hopper Insecticide. Jour. Econ. Ent., Vol. 22, April, 1929, pp. 345–353.

(2) D. M. DeLong et al. Plant as a Factor in the Action of Bordeaux Mixture as an Insecticide and Toxicity of Copper to the Potato Leafhopper. Jour. Econ. Ent., Vol. 23, pp. 383–394, 1930.

The Mediterranean fruit fly fed very generously and abundantly on all the copper-syrup-sugar mixtures introduced into its cages.

The symptoms of death from copper were quite similar to those from arsenic. The flies became weak and unable to fly and within a few hours all motion would cease. Occasionally an individual would lie on its back and move its appendages for more than 24 hours.

Materials Tested and Method of Tests

The syrup used was a very cheap grade of black-strap molasses and the sugar was of a coarse brown grade. In mixing the insecticides the syrup and sugar were first added to the water and the insecticide then made into a paste and added. The lead arsenate used was of a standard brand and the copper carbonate was chemically pure with the following formula, $CuCO_3.Cu(OH)_2$; however, commercial grades of copper carbonate bought on the market gave equally good results.

All of the work was done with Mediterranean fruit flies reared at Orlando, Florida, in the insectary or in cages built for that purpose. Since this is the case, the age, treatment, feeding, handling, and many other important items relative to insects used for toxicity work were known. For each experiment twenty-five flies (per jar or test) of the same age and treatment were selected. These were placed either in a glass pint jar or a cheese-cloth cage of the same size. The insecticide was sprayed either on leaves or cheese cloth and these were introduced into the cage. All dead flies were counted at intervals of twenty-four hours, and the numbers recorded.

Results with Copper Carbonate and Lead Arsenate

The results or conclusions of this work are based on 90 tests of 25 flies each with copper carbonate (2,250 flies) and 71 tests of 25 flies each with lead arsenate (1,775 flies). Some 6,000 more flies were used for checks and other materials most of which are reported in this paper. In order to show the results actually obtained with copper carbonate and lead arsenate a table is given showing a summary of a few of the experiments with various mixtures of the materials. (See Table 1.)

A diagram in which the toxicities of lead arsenate and copper carbonate are compared, the accumulated per cent dead being plotted against time, is shown in Figure 76, 1. It will be readily noted that the curve for lead arsenate is somewhat steeper than that for copper carbonate and the time to kill 50 per cent is approximately a day shorter. The mean length of life of fruit flies caged with the insecticide is $3.69 \pm .034$ days for lead arsenate and $4.43 \pm .05$ day for copper carbonate.

TABLE 1. TOXICITY OF LEAD ARSENATE AND COPPER CARBONATE TO ADULTS OF THE MEDITERRANEAN FRUIT FLY

Material	Date 1929	Avr. Temp. for Period °F.	Age Flies Used Days	Per cent Dead in Specified Number of Days 1	2	3	4	5	6	7	Number of Tests	Number of Flies
Check, water 190 gal.... Syrup 10 gal.... Sugar 50 lbs....	9/17 to 11/10	75.2	3–5	1.5	4.3	6.8	8.8	14.7	17.1	—	24	600
Check, water....	9/17 to 11/10	75.2	3–5	1.3	9.3	46.6	96.0	98.0	98.0	—	3	75
Lead Arsn. 4 lbs.. Syrup 5 gal..... Sugar 25 lbs.... Water 195 gal....	10/20 to 11/4	74.9	3–5	1.1	27.7	82.3	98.0	100	——	—	7	175
Lead Arsn. 8 lbs.. Syrup 10 gal..... Sugar 50 lbs.... Water 190 gal....	9/17 to 11/4	75.4	3–5	.4	11.7	46.0	79.7	93.2	100	—	18	450
Lead Arsn. 16 lbs. Syrup 10 gal..... Sugar 10 lbs.... Water 190 gal....	9/27 and 9/30	74.0	3–5	0	44.0	74.0	84.0	96.0	100	—	4	100
Lead Arsn. 8 lbs. Water 200 gal....	9/25 and 9/27	78.9	3–5	0	26.0	96.0	100	——	——	—	2	50
Check, syrup 10 gal..... Sugar 50 lbs.... Water 190 gal....	9/17 to 11/10	75.2	3–5	1.5	4.3	6.8	8.8	14.7	17.1	—	24	600
Cu Carbonate 8 lbs. Syrup 5 gal..... Sugar 25 lbs.... Water 195 gal....	10/17	71.8	3–5	0	8.0	8.0	24.0	92.0	96	—	1	25
Cu Carbonate 8 lbs..... Syrup 10 gal..... Sugar 50 lbs.... Water 190 gal....	9/25 and 10/4	78.9	3–5	2.0	4.0	4.0	28.0	48.0	84.0	100	2	50
Cu Carbonate 12 lbs..... Syrup 1 gal..... Sugar 50 lbs..... Water 190 gal....	10/4	74.3	3–5	0	8	16	20	28	52	96	1	25
Cu Carbonate 16 lbs..... Syrup 1¼ gal.... Sugar 6¼ lbs.... Water 198¾ gal..	10/2	72.0	3–5	0	8	8	32	60	100	—	1	25

TABLE 1 (*continued*)

Material	Date 1929	Avr. Temp. for Period °F.	Age Flies Used Days	Per cent Dead in Specified Number of Days 1	2	3	4	5	6	7	Number of Tests	Number of Flies
Cu Carbonate 16 lbs. Syrup 2½ gal. Sugar 12½ lbs. Water 197 gal.	10/2	72.0	3–5	0	12	20	28	68	100	—	1	25
Cu Carbonate 16 lbs. Syrup 5 gal. Sugar 25 lbs. Water 195 gal.	10/2 and 10/8	72.0	3–5	4	6	10	30	68	96	100	2	50
Cu Carbonate 16 lbs. Syrup 7½ gal. Sugar 37½ lbs. Water 192 gal.	10/8	75.2	3–5	0	0	0	24	75	100	—	1	25
Cu Carbonate 16 lbs. Syrup 10 gal. Sugar 50 lbs. Water 190 gal.	9/30 to 11/10	70.4	3–5	4.7	14.6	28	52.7	66.2	96	100	9	225
Cu Carbonate 16 lbs. Syrup 20 gal. Sugar 100 lbs. Water 180 gal.	10/2	72.0	3–5	0	8	20	28	52	52	96	1	25
Cu Carbonate 16 lbs. Syrup 40 gal. Sugar 200 lbs. Water 160 gal.	10/2	72.0	3–5	0	12	16	32	48	48	72	1	25
Cu Carbonate 18 lbs. Syrup 10 gal. Sugar 50 lbs. Water 190 gal.	10/4	74.3	3–5	8	8	8	16	44	60	100	1	25
Cu Carbonate 24 lbs. Syrup 10 gal. Sugar 50 lbs. Water 190 gal.	10/4	74.3	3–5	0	0	0	16	20	52	100	1	25
Cu Carbonate 32 lbs. Syrup 10 gal. Sugar 50 lbs. Water 190 gal.	9/30	77.7	3–5	12	40	56	92	100	—	—	1	25

Factors Influencing Toxicity

Anyone who has done toxicity work is well aware that there are a great many factors that cause variations in the results obtained. In

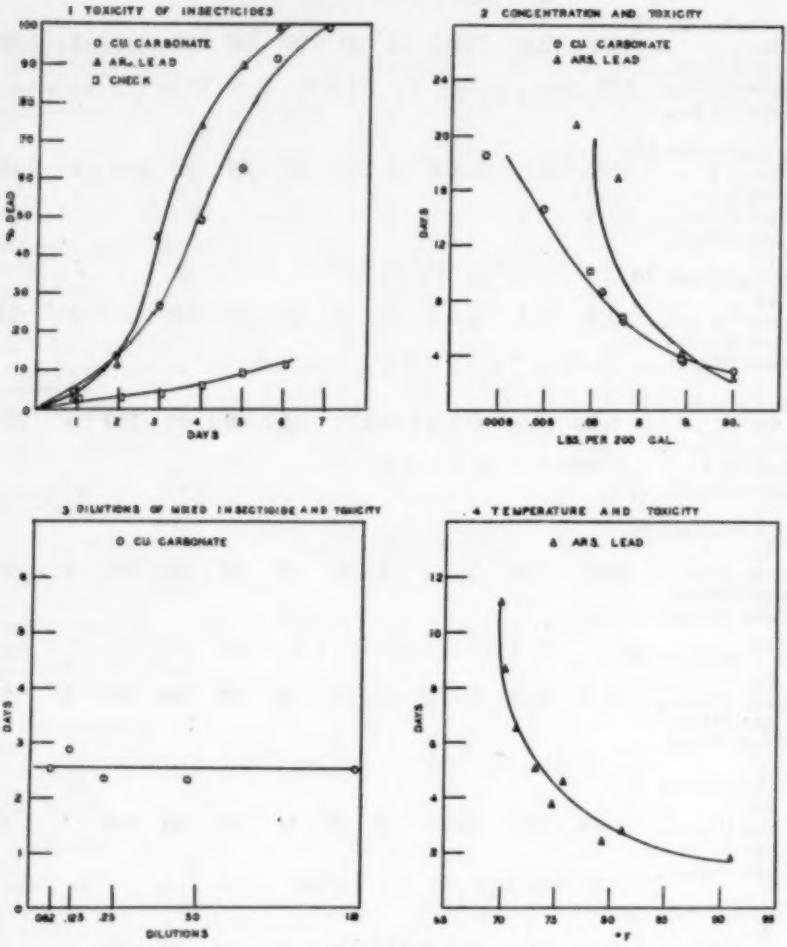

Fig. 76.

this work an attempt was made to measure the effects of some of these factors so that the variations produced might be better understood.

Concentration of Insecticide.—It was found that if the flies were allowed to feed on the insecticide immediately after it was mixed the kill was much more slow than if they were not fed on it until most of the water had evaporated.

As shown in Table 1, lead arsenate was used at concentrations ranging from 4 pounds to 16 pounds per 200 gallons of syrup-sugar mixture, with slightly more rapid kill at the higher concentrations. Copper carbonate was used at dilutions ranging from 8 pounds to 32 pounds per 200 gallons as shown in Table 1, with almost no change in the toxicity at any dilution.

Concentrations ranging from 80 pounds per 200 gallons to 0.08 or 0.008 pound per 200 gallons were used. As was to be expected, the kill was highest at the highest concentrations and the "repellent effect" of copper compounds, if there is any, did not reduce the toxicity. At the low concentrations, copper carbonate was much more toxic than was lead arsenate. The writers have entertained the theory that the copper compounds may be toxic by killing the intestinal flora of the fruit fly and this fact tends to substantiate that belief. Small traces of copper are very toxic to fungus or bacterial organisms, while small quantities of lead arsenate are not. Figure 76, 2 shows the toxicity at various concentrations.

DILUTIONS.—The proportion of syrup, sugar, and insecticide is important, as is shown also by Table 1. The rate of kill was decreased when the quantity of sugar and syrup was doubled or quadrupled in proportion to the quantity of insecticide.

It was found that if the proportions of syrup, sugar, and insecticide were kept the same and only the water varied, the toxicity was not altered. However, when dilutions were made the quantity of insecticide on each individual area was reduced accordingly. (See Figure 76, 3)

TEMPERATURE.—The one factor that probably influences toxicity more than any other is temperature. With lead arsenate the mean length of life ranged from two days at 92° F. to nine to eleven days at 72° F., as shown in Figure 76, 4. In this paper the various experiments were not corrected for temperature variations, so the same insecticide may give one result in one test and another in the next, although each experiment or group shown on one table or one figure was conducted under the same or similar conditions.

HYDROGEN ION CONCENTRATION.—The hydrogen-ion concentration of the suspension of copper carbonate has a very definite relation to the rapidity of kill. The pH was controlled by means of various quantities of buffer solutions, citric acid (.1M) and sodium acid phosphate (.2M). The effect of the pH in this case is influenced by the fact that copper carbonate is soluble in an acid solution. While it is also slightly soluble in an alkaline solution, in this case it is soon reduced to an insoluble copper oxide by the sugars present in the mixture. Flies fed on the

buffer solution in the check lived normally. The hydrogen-ion concentration was measured by a Welch quinhydrone apparatus. The mean length of life ranged from less than two days at pH 2.8 to almost five

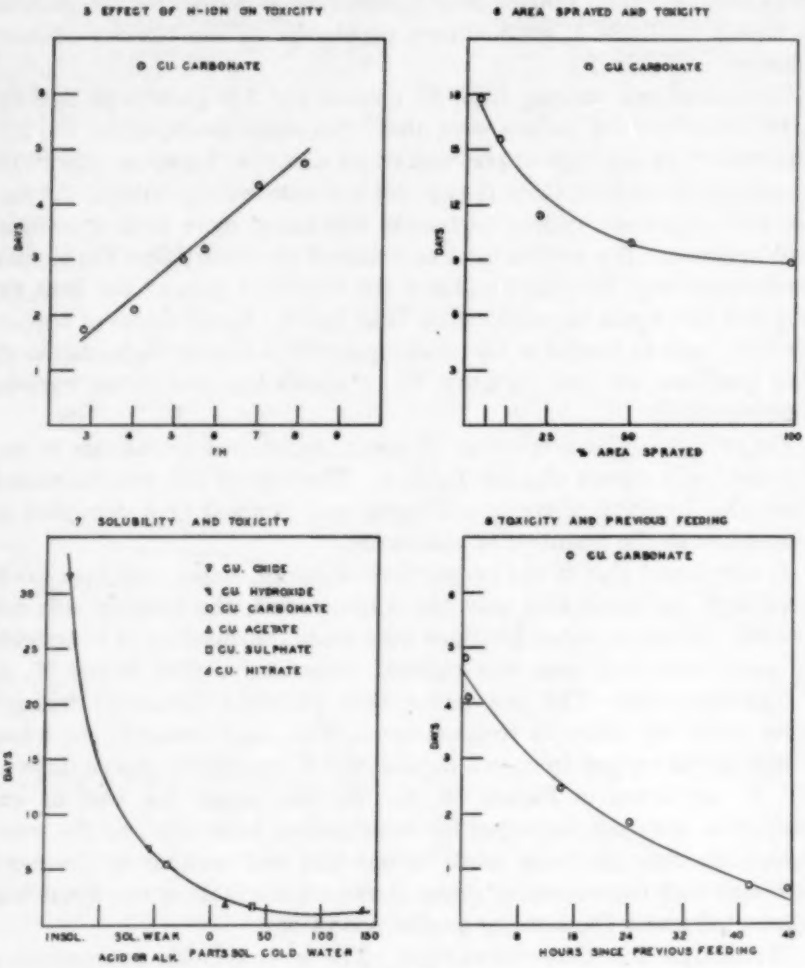

FIG. 77.

days at pH 8. (See Figure 77, 5.) The normal pH of a mixture of copper carbonate, syrup, sugar, and water is 5.6.

RELATION BETWEEN AREA SPRAYED AND TOXICITY.—The greater the area sprayed with insecticide, the more rapid was the kill of the fruit fly. This factor may cause great variation in laboratory results if the worker

is careless in selection of cages or materials. Varying proportions of the inner surfaces of glass pint jars ranging from 6¼ per cent to 100 per cent were covered with lead arsenate. In one case syrup and sugar were used and in the other case lead arsenate and water alone were used. Where syrup, sugar, and lead arsenate were employed there was a coefficient of correlation of — .492 ± .046 between mean length of life and area sprayed, and where only lead arsenate and water were used, a coefficient of correlation of — .615 ± .038 between mean length of life and area sprayed. This seems to indicate that the fly is not attracted to the syrup and sugar. (See Figure 77, 6.)

Solubility of Copper Compounds.—In a general way it may be said that the more soluble the copper compound, the more rapidly will it kill fruit flies. No repellent effects were noted by any of the copper compounds. (See Figure 77, 7.)

Previous Feeding of Flies.—The treatment or previous feeding of fruit flies probably had more influence on the death of flies fed insecticides than any other factor concerning the fly itself. The longer the period from previous feeding to the time of poisoning, the more rapid was the kill. (See Figure 77, 8.)

Other Factors.—Humidity ranging from 25 per cent to 100 per cent, light varying from sunlight to total darkness; and reduced pressure ranging from normal to thirty millimeters below normal outside, were studied, but no marked effect on toxicity was noted by any of these factors. It was observed, however, that if flies were kept at a slightly reduced atmospheric pressure or at a reduced fluctuating pressure they died very rapidly. This was true for both those fed insecticides and those fed normal food.

Results of Toxicity Experiments with Various Chemicals.—In a search for an insecticide safe for the tree and highly toxic to fruit flies, a large number of compounds were tested. The results with certain of these materials on fruit flies are shown in the following table. When experiments were completed, with any material, the arithmetic mean of the lengths of life of the flies after they were caged with the insecticide as food was calculated and is shown on the following page. (Table No. 2.)

Toxicity to Trees.—When arsenic is sprayed on citrus trees some damage to the trees frequently results, depending on the frequency of application, quantity used, method of application, and condition of tree. It was found in spraying that any method of application that caused an accumulation of arsenic and syrup on the tree caused injury. When trees were sprayed during bright sunlight at mid-day when the temper-

TABLE 2. TOXICITY OF VARIOUS CHEMICALS TO THE MEDITERRANEAN FRUIT FLY
(All materials were used in a solution of 50 pounds sugar, 10 gallons syrup and 190 gallons water)

Material Fed Flies	Quantity of Insecticide per 200 Gallons	Mean Length of Life in Days of Flies Exposed to Material in Cages	Condition of Flies in Check When 100 per cent Dead in Insecticide	Number of Tests	Number of Flies
Check, sugar and syrup solution	None	19.52±.023	———	24	600
Antimony Trichloride $SbCl_3$	8 lbs.	1.36±.025	8 per cent	1	25
Barium Carbonate $Ba CO_3$	8 lbs.	4 per cent dead in 5 days	0 per cent dead in 5 days	1	25
Bismuth Trichloride $Bi Cl_3$	8 lbs.	3.68±.151	68 per cent dead	1	25
Bordeaux Mixture 2-2-50.	8 lbs.	3.84±.095	17.1 per cent dead	3	75
Calcium Cyanide $Ca (CN)_2$ 40 per cent	8 lbs.	16 per cent dead in 12 days	12 per cent dead in 12 days	1	25
Cadmium Bromide $Cd Br_2$. $4 H_2O$	8 lbs.	2.72±.122	56 per cent dead	1	25
Copper Acetate $Cu (CH_3 COO)_2.H_2O$	8 lbs.	2.28±.128	16 per cent dead	1	25
Copper Arsenite $Cu H As O_3$	8 lbs.	1.08±.036	4 per cent dead	1	25
Cupric Borate $Cu B_4O_7$. $4H_2O$	8 lbs.	2.48±.161	4 per cent dead	1	25
Copper Bromide $Cu Br_2$	8 lbs.	1.88±.115	4 per cent dead	1	25
Cuprous Chloride $Cu_2 Cl_2$	8 lbs.	6.78±.194	68 per cent dead	1	25
Cupric Chloride $Cu Cl_2$	8 lbs.	2.88±.144	4 per cent dead	1	25
Copper Carbonate $Cu CO_3$. $Cu(OH)_2$	16 lbs.	4.43±.050	17.1 per cent dead	9	225
Copper Cyanide $Cu(CN)_2$	8 lbs.	4.68±.239	16 per cent dead	1	25
Cupric Fluoride $Cu Fe. 2H_2O$	8 lbs.	1.92±.125	4 per cent dead	1	25
Copper Hydroxide $Cu (OH)_2$	8 lbs.	5.68±.240	4 per cent dead	1	25
Copper Nitrate $Cu (NO_3)_2$. $3H_2O$	8 lbs.	2.96±.110	8 per cent dead	1	25

ature was near 90°F., damage usually resulted. If the spray material was driven into the tree with too much force this also caused the leaves to drop and the smallest twigs to be killed. Trees that were growing poorly or were in a general run-down condition were injured much more readily than were those in better state of growth.

In order to compare the effects of lead arsenate and copper carbonate, a series of twenty daily sprayings were made with a knapsack sprayer. In the case of lead arsenate three times as many leaves fell as with the copper carbonate mixture. The syrup and sugar solutions caused considerably more leaves to fall than fell from the check trees, as shown in Table No. 3.

TABLE 2 (*continued*)

Material Fed Flies	Quantity of Insecticide per 200 Gallons	Mean Length of Life in Days of Flies Exposed to Material in Cages	Condition of Flies in Check When 100 per cent Dead in Insecticide	Number of Tests	Number of Flies
Copper Oxalate Cu C_2O_4. ½ H_2O	8 lbs.	3.48±.173	36 per cent dead	1	25
Copper Oxide Cu_2O	8 lbs.	23.00±2.20	100 per cent dead	1	25
Copper Sulphate Cu SO_4. $5H_2O$	8 lbs.	2.88±.117	8 per cent dead	1	25
Copper Sulphite Cu_2SO_3. H_2O	8 lbs.	2.84±.112	4 per cent dead	1	25
Copper Tartrate Cu $C_4H_4O_6$.3 H_2O	8 lbs.	2.28±.138	4 per cent dead	1	25
Derris Emulsion 5 per cent Derris Resin	1 pt.	80 per cent dead in 9 days	12 per cent dead in 9 days	1	25
Ferrous Sulphate $FeSO_4$. $7H_2O$	8 lbs.	16 per cent dead in 6 days	12 per cent dead in 6 days	1	25
Lead Arsenate PbH As O_4	8 lbs.	3.69±.034	14.7 per cent dead	18	450
Lime Sulphur 32 Beaumé	4 gal.	48 per cent dead in 12 days	12 per cent dead in 12 days	1	25
Mercuric Chloride $HgCl_2$	8 lbs.	.96±.025	16 per cent dead	1	25
Magnesium Sulphate Mg SO_4	8 lbs.	5.05±.224	84 per cent dead	1	25
Nicotine Sulphate (40 per cent nicotine)	1 pt.	1.68±.072	4 per cent dead	1	25
Potassium Aluminum Fluoride K_3AlF_6	8 lbs.	20 per cent dead in 6 days	17.1 per cent dead in 6 days	1	25
Pyrethrum Emulsion 46 per cent Active Ingredients	1 pt.	76 per cent dead in 9 days	4 per cent dead in 9 days	1	25
Sodium Benzoate Na $C_7H_5O_2$	8 lbs.	3.08±.121	0 per cent dead	1	25
Stannous Chloride $SnCl_2$. $5H_2O$	8 lbs.	4.88±.36	84 per cent dead	1	25
Thallium Sulphate Tl_2SO_4	8 lbs.	1.52±.138	8 per cent dead	1	25
Zinc Chloride $ZnCl_2$	8 lbs.	2.92±.120	56 per cent dead	1	25

EFFECT ON CITRUS FRUIT.—It has been known for many years that arsenic sprayed or dusted on citrus trees in certain quantities or under certain conditions will cause the acid present in the next crop of fruit to be reduced. In order to determine the effects of different quantities of arsenic, various experiments were undertaken. One of these used from one-half pint to four gallons of the material per tree in one application when the fruit was about one to two inches in diameter.

Lead arsenate when used at the rate of one-half gallon per tree with the power equipment, and two gallons per tree with the knapsack equipment, had a very marked effect on the citric acid-soluble solids ratio. As the season advanced, the ratios of the sprayed fruit increased

at first slowly, but later rapidly. The ratios of the power-sprayed fruit increased at a faster rate and reached a higher peak than those of the fruit sprayed with knapsack equipment.

TABLE 3. SHOWING EFFECT OF TWENTY DAILY APPLICATIONS OF INSECTICIDE MIXTURE ON SEEDLING ORANGE TREES FIFTEEN YEARS OLD

Insecticide	Quantity Applied	Tree No.	Total Number of Leaves Falling per Sq. Yd. in 29 Days	Average Number Falling
8 lbs. Arsn. Lead, 50 lbs. Sugar, 10 gal. Syrup, 190 gal. Water	1 pt.	1	355	
	1 pt.	2	476	415.5
	1 qt.	1	507	
	1 qt.	2	1,996	1,251.5
16 lbs. Cu Carbonate, 50 lbs. Sugar, 10 gal. Syrup, 190 gal. Water	1 pt.	1	106	
	1 pt.	2	130	118.0
	1 qt.	1	327	
	1 qt.	2	251	289.0
50 lbs. Sugar, 10 gal. Syrup, 190 gal. Water	1 pt.	1	91	
	1 pt.	2	271	181.0
	1 qt.	1	226	
	1 qt.	2	298	262.0
Check	—	1	28	
No treatment	—	2	14	
		3	8	
	—	4	17	16.77

The ratios resulting from the various quantities of material are shown in Table No. 4.

TABLE 4. AVERAGE RATIOS OF ANHYDROUS ACID TO TOTAL SOLUBLE SOLIDS IN FRUIT SPRAYED ONCE WITH LEAD ARSENATE 8 POUNDS, SYRUP 10 GALLONS, SUGAR 50 POUNDS, WATER 190 GALLONS, WHEN FRUIT WAS ONE TO TWO INCHES IN DIAMETER

Quantity	Knapsack Sprayer *Ratio*	Power Sprayer *Ratio*
½ pint	1- 8.75	1- 6.75
1 pint	1-11.40	1-11.10
1 quart	1- 8.80	1- 9.60
2 quarts	1-10.25	1-16.30
1 gallon	1- 7.80	1-18.25
2 gallons	1-15.20	1-14.60
4 gallons	1-13.50	1-17.75
Check, no treatment	1-9.27	

When some fruits on a sprayed tree were enclosed in paper bags so that no spray material reached them but the leaves around them were sprayed, they were affected just as much as if they had been sprayed. The effect of arsenic on the fruit, therefore, is carried through the

leaves and branches to the fruit. Dipped fruit on trees where the foliage has not been sprayed is affected the same as that on foliage-sprayed trees, while the remaining fruit on the tree shows no effect. When only the fruit is treated, it alone is affected, while the tree and remaining, untreated fruits are not affected.

While the writers have no extensive data on the effects of copper compounds on citrus trees, copper has been used on such trees in Florida for many years with beneficial effects. It has been sprayed as Bordeaux and used on the soil as a conditioner and cure for the diseases known as "Dieback." In all its use, it has not been found to influence fruit ratios or to harm the trees unless used in excess.

SUMMARY.—Copper compounds have been found to be very toxic to the Mediterranean fruit fly when used in a solution of syrup and sugar. The mean length of life of fruit flies fed on a mixture of 8 pounds lead arsenate, 50 pounds sugar, 10 gallons syrup and 190 gallons water was $3.69 \pm .034$ days after they had been caged with the insecticide. Copper carbonate used at the same strength gave a mean length of life of $4.43 \pm .050$. The copper compounds had no repellent effect on fruit flies, but were most toxic at the highest concentration although remaining quite toxic at very low concentrations. Insecticide mixtures may be diluted with water without reducing toxicity as long as the proportions of insecticide, syrup, and sugar are maintained the same.

A temperature of 92°F. caused flies to die from three to five times as fast as they did at 72°F. when they were fed lead arsenate mixture. Copper carbonate is much more toxic in an acid than in an alkaline suspension. The greater the area covered with the poison to which the flies are exposed, the more rapid is the kill. In copper compounds, the more soluble the compound, the more toxic it is to fruit flies. The longer fruit flies have gone without food, the more rapid will be the kill when they are fed insecticide.

Copper carbonate does much less injury to citrus trees than does lead arsenate and very little more than does a solution of syrup and sugar alone. When the fruit is small, lead arsenate, used with the power spray equipment at the rate of one-half gallon per tree, and with knapsack equipment, at the rate of two gallons per tree, reduced the anhydrous citric acid in the fruit to nearly one-half the normal amount.

THE PALE-STRIPED FLEA BEETLE, A PEST OF YOUNG SEEDLING ONIONS

By C. J. Drake and Halbert M. Harris, *Ames, Iowa*

Abstract

An account of *Systena blanda* as an onion pest.

On June 2, 1931, Mr. H. H. Meuller, an onion grower of St. Ansgar, Iowa, reported that an "onion maggot" of strange appearance and peculiar habits was destroying practically all of his seedling onions. From Meuller's description of the larva and its work, it was quite apparent that some uncommon and perhaps new onion pest was doing serious injury to the crops of young seedling onions in Mitchell County.

A trip to the infested area disclosed that the larvae were those of some species of flea beetle. At that date, June 5, over 75 per cent of the larvae had secreted themselves in small earthen cells in the upper two inches of the soil and had changed to the prepupal and pupal stages. Their feeding had resulted in the total destruction of eight acres of seedling onions. In another field of 13½ acres, the loss was conservatively estimated at 75 per cent of the young plants. On a farm adjoining the latter field the larvae had taken about ten per cent of the seedlings in a twenty-acre field. Reports of many other growers indicated that the pest was widely distributed and generally harmful, though to a lesser extent than on the Meuller farm, throughout the St. Ansgar and Clear Lake onion growing districts.

On June 5, sixty larvae were collected while feeding on the seedling onions, divided into lots of five, and placed in metal salve boxes with a small amount of soil and a seedling onion. On June 6, one hundred more larvae were collected and similarly divided into lots and placed in salve boxes. These were then transported to the Insectary at Ames where examinations were made and new food added daily. The first pupal cell was formed on June 7 and the last of the 160 larvae ceased feeding and entered the prepupal stage on June 23. The first adults emerged on June 20, revealing that the culprit was none other than the pale-striped flea beetle, *Systena blanda* (Melsheimer). At that date newly emerged adults were already present in the gardens about Ames where they had been feeding on the foliage of Calendula, egg-plant, and other common plants in the College gardens. As the imagoes emerged they were placed in cages containing potted Dandelion (*Taraxacum officinale* Weber) and Lamb's Quarters (*Chenopodium album* Linn.)

plants. In these cages the foliage of the Lamb's Quarters was devoured avidly while that of the Dandelion remained scarcely touched. Mating was first observed in the breeding cages on June 23 and egg deposition started on June 27.

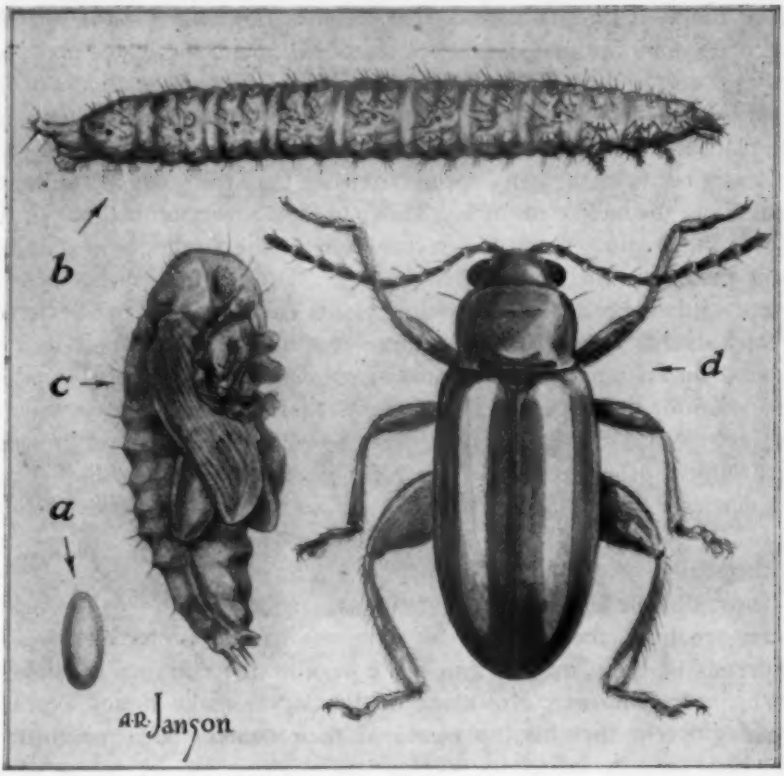

FIG. 78.—Life History of Pale-striped Flea Beetle; *a*, egg; *b*, larva; *c*, pupa; *d*, adult.

The attention of the growers was first attracted to the depredations of this pest by the appearance of many wilted, dying, and dead plants in the seed rows soon after the seedlings had appeared above ground. This injury was occasioned by the larvae gnawing small irregular cavities on the sides of the underground portions of the leaf sheath, cutting through the rootlets, eating into the base of the stem, destroying the bud, and occasionally even tunneling through the underground parts of the plantlet. In most cases only a single larvae was found gnawing into

each seedling, but in several instances two, three or even four were observed feeding on a single plant. The larvae are quite active and readily make their way through the soil, and thus each accounts for the death of from one to several of the extremely tender young seedlings.

The first evidence of attack on a plant is the loss of turgidity at the tip of the seed leaf. Gradually this extends downward, the leaf wilts and droops, its tip turns yellowish, then brown, and the whole plant becomes flaccid and death ensues. However, in the case of the attacks of the older larvae where a relatively large amount of tissue is rapidly destroyed, the plantlet wilts and dies very suddenly.

Losses occur in the early spring from the time the seeds are sprouted until about the middle of June. This period is a very critical one in the life of the seedling onion and coincides with the feeding and development period of the over-wintered larvae. Thus before the grower is aware of their presence, his seedling plants have suffered to a lesser or greater extent from the subterranean-feeding larvae. When seed is planted for set purposes the depredations of the pest are not so marked on account of the large number of plants, and simply result in a thinner or poor stand. These plants, here and there, relieved of their crowded environment often become too large for set purposes. The most damage, however, is confined to seedlings grown for food purposes or commercial onions, no damage having been observed on set onions and mother bulbs.

Through their habits of gnawing into the underground portions of the young seedlings, the larvae break away the natural protective layer or epidermis of the plant and thus make possible the entrance of disease-producing organisms. Not alone do the larvae make these favorable avenues of entrance but, by means of their contaminated mouthparts, they may actually inoculate the plant with pathogenic organisms which they have encountered in their wanderings through the soil or even may carry these from one plant to another.

The injury of the larvae of the pale-striped flea beetle is more marked on onions growing on upland or well drained ground. Losses are heaviest during dry seasons unfavorable for the rapid development of the seedlings. Under these conditions, the tender seedlings are very susceptible to attack, easily injured, and readily succumb to the feeding activities of the larvae. As illustrated in Fig. 79, the gnawing of the larvae at the base of the plant (*b*), on the sides of the underground portion of the thin sheath of the leaves (*c*) or on the rootlets (*d*) seriously affects the young plant, frequently resulting in its sudden death. Al-

though damage is quite noticeable during favorable growing seasons, the mortality of the seedlings is not so high and more plants survive the attacks of the larvae.

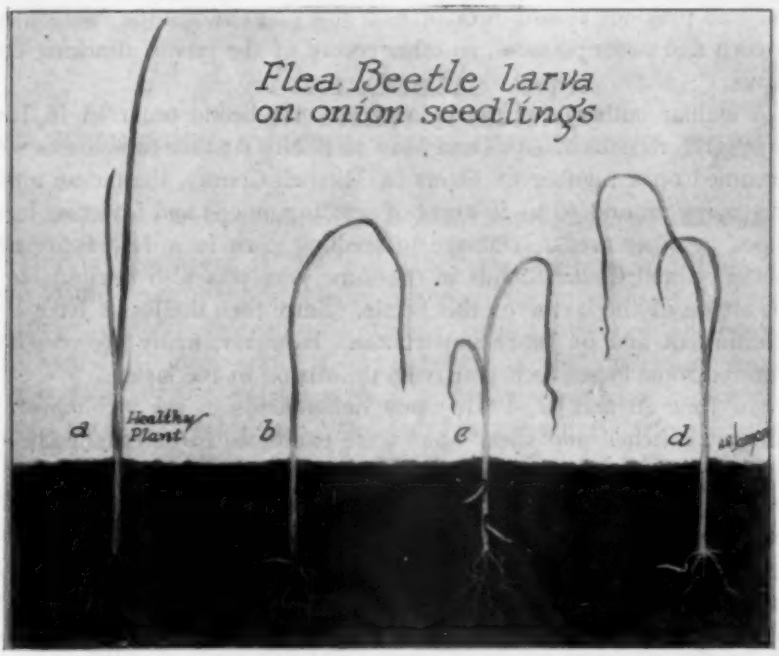

FIG. 79.—Work of Pale-Striped Flea Beetle on Seedling Onion: *a*, healthy seedling; *b*, *c*, and *d*, larvae feeding on seedlings.

The degree of infestation in a given field depends to a certain extent upon the preceding crop. In Mitchell County the heaviest losses in 1931 were sustained in fields following soybeans, potatoes, and cabbages, but as these were in adjoining tracts it was difficult to judge their relative importance. It seems plainly evident, however, that when onions follow onions, and in fields where weeds are systematically destroyed, there is not the likelihood of injury as when onions follow some other crop which does not permit of such clean culture and which is more attractive to the feeding and ovipositing adults.

The pale-striped flea beetle is widely distributed in North America. By some authorities it is considered to be only a pale form of the banded flea beetle, *Systena taeniata* (Say). In the literature concerning the species many records were found of injury to various crops by the adults. These

economic plants together with the various weeds upon which the insect has been known to feed comprise a host list of over fifty species. On all of these, however, the injury recorded is caused by the adult beetles gnawing the characteristic shot-like holes in the foliage. There seems to be no previous record of onion as a host plant and, aside from injury to corn and sweet potatoes, no other record of the larvae attacking crop plants.

A similar outbreak of the pale-striped flea beetle occurred in Iowa during the months of April and May of 1924. At that time losses were sustained on a number of farms in Mitchell County, the larvae totally destroying around 40 to 50 acres of seedling onions and inflicting lesser losses in other areas. Damage to seedling corn in a few fields near Waterloo and Cedar Rapids in the same year was also attributable to the attack of the larvae of this beetle. Since then the losses have been intermittent and of lesser importance. However, many growers have suffered some losses each year from the attacks of the larvae.

On June 26 and 27, 1931, many onion fields in the vicinity of St. Ansgar, Mitchell and Clear Lake were examined to determine the extent of damage resulting from the feeding activities of the larvae on seedling onions and the abundance of the newly emerged beetles. Attention was also given to soybeans, potatoes, cabbage, and other crops grown in an irregular rotation on onion ground. In every onion field the adult beetles were found feeding on weeds, the abundance of the beetles varying with the prevalence of the wild host plants. This was especially noticeable in fields containing areas seriously injured by the beetle larvae leaving therein poor stands. The cultivation, especially the hand-weeding, in such areas had been more or less neglected resulting in a somewhat weedy condition. In the case of soybean fields the wild hosts were much more abundant than in the onion fields. This, coupled with the fact that the beetles also feed on the leaves of soybeans, seems to account for the more serious injury on the seedling onions following soybean as a green-manure or cover crop.

Foliage of Lamb's Quarters (*Chenopodium album* L.), Purslane (*Portulaca oleracea* L.), Rough Pigweed (*Amaranthus retroflexus* L.), and White Clover (*Trifolium repens* L.) were almost totally destroyed by the feeding activities of the adults. Round Leaf Mallow (*Malva rotundifolia* L.) and Spotted Smartweed (*Polygonum persicaria* L.) also served as important hosts. Foxtail (*Setaria glauca* L.) was noted in only one instance to be injured by the beetles.

In conclusion it may be stated that the work of the larvae of the pale-

striped flea beetle is generally overlooked by the grower or is confused with that of the various species of onion maggots. This is due largely to the fact that the larvae are small and difficult to find, feed beneath the surface of the soil on the outside of the plantlet, and remain in the ground when the seedling is pulled out by hand.

SOME FIELD OBSERVATIONS ON CODLING MOTH BEHAVIOR

By ARTHUR D. BORDEN, *Assistant Entomologist, University of California*

During the seasons of 1928 and 1929 the writer participated in a field test of the effect of artificial light on the egg laying habits of the codling moth (*Carpocapsa pomonella* Linn.)[1] which afforded an excellent opportunity to make many observations of unusual interest concerning the behavior of this insect. A block of fifteen apple trees in an orchard near Sebastopol, California, was flooded each evening during the sunset period for about three hours from April 26th to June 30th in 1928 and from April 25th to October 24th in 1929—six 500 watt lights being used in 1928 and eighteen 500 watt lights during 1929. This experiment permitted us not only to observe the moth activities during this period but also provided data on temperature, humidity, light intensity and bait trap catches.

Even with the increased light intensity of the 1929 experiment it is apparent from our results that the artificial lights did not deter the moth in its activities sufficiently to affect our observations. Light intensity readings about the trees when only the artificial light was present gave not more than four foot candle which is much less than the natural light intensity around the sunset period or the time of maximum flight.

The flight of the moth is undoubtedly greatly governed by several ecological factors including light intensity, humidity, temperature and air movement. It is generally known that the moth only flies about the sunset period but few actual records are available. The accompanying table shows that flight may extend over a period of approximately two hours under favorable conditions or there may be no flight at all when the temperature is too high, or too low or when it is too windy. Our records show a maximum flight period of one hour and fifty-three minutes in August and from that on down to no flight at all. It is interesting

[1]HERMS, W. B., Jr. Econ Ent. Vol. 22, No. 1, February, 1929.

to note that the maximum number of moths in flight for any one evening does occur in the period immediately before or immediately after sunset and usually within twenty minutes previous or twenty minutes following sunset. Our light intensity records adjoining the tree area at that period show a range of from twenty-five to fifty-two foot candle. The average 'outside' or normal sunset intensity at the same period is twenty-nine and nine-tenths foot candle. The variance in the tree area is due to the effect of shadow or slanting rays of light in the higher tops.

The time at which the first moth has been repeatedly observed to appear is previous to sunset and when the sunlight is still on the upper third of the tree with the lower two-thirds in shadow. The flights at this time are very short and close to the tree. Then as the light intensity decreases the flights widen and are of longer duration. Usually, however, the moth does not sustain its flight for any great distance for it has repeatedly been observed to travel along the upper third of the tree for a distance of from two to three trees in the row (a distance of from fifty to seventy-five feet) but rarely more than that. Individual moth have been observed to line out on a long flight without relation to tree tops and travel for considerable distances. This matter of flight has also been checked by use of bait traps in tree rows adjoining driers and packing sheds, where moth are known to emerge in great numbers, and it shows that there is not any great increase in the numbers taken after the fifth or sixth row from the emergence place. Observations on the percentage of wormy fruit in these rows verified the results obtained with the bait pans.

The manner of flight of the Codling Moth is very characteristic and after a little study it may be readily identified from that of leafrollers, skinworm, and other insects in flight at the same period. It may be described as a quick, zig-zag movement at various angles and may rise or drop rather suddenly. Too frequently the orchardist mistakes the rather even flight of the leafroller for that of Codling Moth. The moth will rise from the foliage of one tree and after flitting about outside the foliage will either alight or travel on to an adjoining tree. Upon alighting on a leaf they usually are very quiet in the early part of the evening but if it is near the sunset period they often very busily inspect both sides of the leaves or fruit and finally select a leaf surface or occasionally a fruit surface to deposit an egg. Many of the eggs are very apparently deposited in the early season not on the small fruit but on the smaller leaves immediately adjoining a fruit cluster. The time taken to deposit an egg is usually very short—not over a minute or two. Having

selected a suitable spot the female starts brushing the surface of the leaf or fruit with the tip of the abdomen by a somewhat rolling motion of the whole abdomen and within a very few seconds the egg appears as a flat, shiny disc. The moth immediately moves away or may even take flight. Only occasionally do they deposit two or more eggs on the same fruit or leaf. As shown in the following table of egg depositions, which were observed in the field, the deposition occurred within the sunset period and at temperatures ranging from 60 to 69°F.:

Date	Time	Sunset Time	Temp.	Light Intensity
May 2	7:45	6:55	67	12 f.c.
11	7:10	7:04	62	—
13	7:20	7:08	60	—
Aug. 18	7:07	6:52	65	10
18	7:15	6:52	64	5.8
22	6:42	6:46	69	11
27	7:00	6:40	67	7.3
Sept. 10	7:15	6:18	64	3.3

Undoubtedly some eggs are deposited before and after this so-called sunset period but from the movement of the moth during this period there is little doubt but what the majority of the eggs are deposited within this period.

As given above the flight is governed by temperature, humidity, light intensity and air movements. Just which of these are the most important is difficult to state; however light intensity, temperature and air movements seem to play a very important role. In the Sebastopol district, which has a relatively low humidity as compared with the Watsonville district, a rise in temperature gives a decided drop in humidity. The appearance of the fog from the coast in the early evening very quickly drops the temperature and stops moth flight. The maximum temperature at which flight has been observed to a start is 78° F. and the minimum temperature for this district is 54° F. Usually, however, moth flight ceases at about 58° F. at Sebastopol, while in the Watsonville district 55° F. seems to be the average minimum. Too high temperatures in the early part of the evening have shown a decided check on moth flight as shown in the Table during the months of June and July.

The range in light intensity is comparatively wide, though as noted above the maximum activity occurs within the range of from 25 to 52 foot candle. Observations have been made of moth in flight at 1928 foot candle and to have caused flight at .3 foot candle. Bright sunlight undoubtedly checks them as does darkness for few if any moth are ever taken in the pans excepting between the hours from five to ten o'clock in the evening.

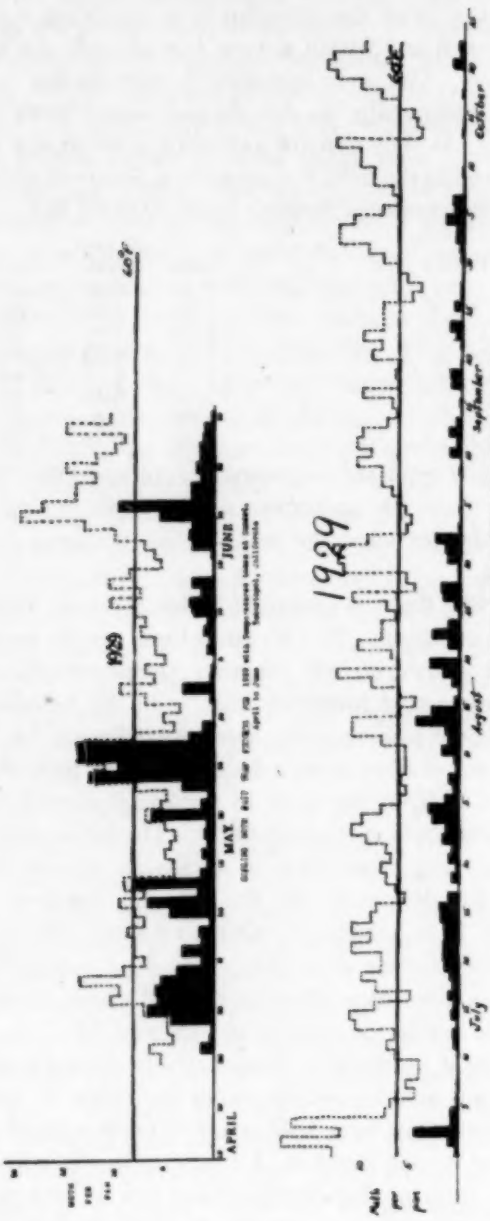

FIG. 80.

One of the most notable factors in the field in controlling flight is the starting of a breeze or wind. Just the faintest air movement over the tree tops effectively cut down the flight and evenings when a wind was blowing very few if any moth were observed even though the temperature and light intensities were still favorable. The few moth that did arise on these evenings kept very close to the trees and were comparatively inactive.

A study of the catch of the bait traps has shown that very seldom do we take moth except during the sunset period and that there is a decided increase in the moth taken at this period whenever the temperature is over 60° F. Only twice in the season did we observe what might have been a sunrise flight. On June 20th and 21st the temperatures at sunrise were sufficiently high to permit flight and as the flight the previous evenings was very poor and only a very few moth were noted in the pans at 10 P. M. we were surprised to find a goodly number of moth when the pans were cleaned the following morning. This abnormal morning temperature condition was during a two day heat spell for usually the sunrise temperatures are too low for flight. The same thing occurred on July 2nd following another evening of high temperature and with a sufficiently high morning temperature.

Mating has been repeatedly observed during the period of moth flight. The male may find the female in flight and follow her to the foliage where the female busily moves about with her wings fluttering over her back and the male following closely. In copulation the male is headed in the opposite direction from the female and with tips of the abdomens clasped together and the tips of the wings of the male under those of the female. Copulation has been observed to occur for a period of from 20 minutes to one hour and 20 minutes. On several different evenings a number of moth were observed to be congregated in flight about the high top of a tree. Closer observation revealed it to be fifteen or twenty male moth swarming about one or more females. Only after the swarming had ceased were the females observed to be copulated. That the females do attract the males by their quick movements and fluttering wings has repeatedly been observed.

Our observations show that the catch of the bait pans are fairly accurate in indicating moth activity though only comparatively few moth are taken each evening per pan for the number of moth observed in flight about the tree in which the pan is suspended. The value of the bait trap lies in that it does more accurately indicate these evenings of greater moth activity than any former method and with observations

as to prevailing temperatures at sunset we may determine with more certainty the proper time to make the spray applications to give the most efficient control. On evenings of too low temperatures during the sunset period or when the wind interfered with moth flight very few moth were taken in the pans. The maximum catches were invariably on evenings ideal for moth activity which followed peaks of emergence. The economic value of the bait trap has been proven in the Sebastopol district during the past four fruit seasons.

TABLE SHOWING OBSERVED SUNSET TIME, CODLING MOTH FLIGHT, WEATHER CONDITIONS AND BAIT TRAP CATCHES FROM APRIL 24TH TO OCTOBER 24TH, 1929 AT SEBASTOPOL, CALIFORNIA

	Sunset		Moth Flight							
		Temp.	First Moth	Temp.	Maximum Time	Temp.	Last Moth	Temp.		Moth Trap
Date	Time	F	Time	F		F	Time	F	Weather	Catch*
April 24...	6:47	55	6:30	58					Breeze	—
25...	6:48	57	6:30	59	6:38	58	6:50	57	Clear	13
26...	6:49	52							Breeze	0
27...	6:50	53							Breeze	3
28...	6:51	53	5:45	56					Breeze	1
29...	6:52	58	5:42	63	6:00	53	7:08	57	Clear	44
30...	6:53	65			6:52	64			Clear	69
May 1....	6:54	63	5:40		6:21		7:38	58	Clear	59
2....	6:55	71	6:21	74	6:55	71			Clear	60
3....	6:56	62	No record						Clear	56
4....	6:57	60	No record						Clear	39
5....	6:58	60	No record						Breeze	13
6....	6:59	59	No record						Clear	32
7....	7:00	61	No record						Breeze	13
8....	7:01	60	No record						Breeze	16
9....	7:02	56	6:20	60	6:45	58	7:30	55	Windy	3
10....	7:03	60	6:15	68	6:45	60	7:20	56	Clear	47
11....	7:04	63	5:15	79	7:00	63	7:35	57	Clear	69
12....	7:05	58	5:30	70			7:15	56	Clear	17
13....	7:06	61	5:20	70	6:40	65	7:30	58	Clear	82
14....	7:07	52	5:20	58			5:30	58	Fog-wind	13
15....	7:08	52	5:30	60					Breeze	8
16....	7:09	54	5:25	65	6:00	60	6:30	58	High fog	12
17....	7:09	53	5:20	61			6:10	58	High fog	7
18....	7:10	52	5:15	58			5:45	56	High fog	10
19....	7:10	54	5:25	62			5:25	62	High fog	9
20....	7:11	58	5:40	66	6:20	63	8:05	54	Clear	64
21....	7:11	55							Windy	13
22....	7:12	54	6:10	60			6:10	60	Windy	7
23....	7:13	60	5:20	74	6:45	64	8:05	56	Clear	31
24....	7:14	68	5:30	78	6:45	70	8:10	64	Clear	127
25....	7:15	63	5:40	69	6:40	65	8:00	60	Clear	97
26....	7:15	63	6:50	65	7:25	62	8:05	60	Clear	138
27....	7:16	64	6:15	71	7:35	62	8:08	58	Clear	139
28....	7:17	60	5:20	71	7:00	62	7:40	56	Breeze	24
29....	7:18	52	5:40	62					Fog-wind	6
30....	7:19	54							Fog-wind	0
31....	7:20	51							Fog-wind	0

*The total catch of moth from ten bait pans widely separated within and without the lighted area.

TABLE (*continued*)

Date	Sunset Time	Sunset Temp. F	First Moth Time	First Moth Temp. F	Moth Flight Maximum Time	Moth Flight Maximum Temp. F	Last Moth Time	Last Moth Temp. F	Weather	Moth Trap Catch
June 1	7:20	58	6:40	62			6:40	62	Fog-wind	4
2	7:21	63	5:30	72	7:10	65	8:05	57	Clear	31
3	7:22	56							Fog-wind	3
4	7:22	57							Fog-wind	2
5	7:23	54							Fog-wind	0
6	7:23	56	5:50	58			5:50	58	Breeze	6
7	7:24	56	5:20	62			6:35	59	Breeze	5
8	7:25	59							Breeze	10
9	7:26	58	5:45	64			5:45	64	Breeze	7
10	7:26	60	6:02	66	7:00	62	7:33	59	Clear	21
11	7:28	65	6:10	72	7:00	67	8:16	58	Clear	24
12	7:28	59	5:45	72			7:30	59	Breeze	13
13	7:29	65	6:10	72	7:10	67	7:40	63	Clear	21
14	7:29	61	5:35	69			7:50	60	Fog	0
15	7:29	55							Rain	0
16	7:30	56							Breeze	2
17	7:30	58							Clear	21
18	7:31	64	6:28	70			8:25	60	Clear	26
19	7:31	70	6:48	76	7:55	69	8:58	63	Clear	22
20	7:31	83	Poor Flight						Clear	56†
21	7:32	79	8:10	76					Clear	98†
22	7:31	72	8:05	68					Clear	24
23	7:31	72	7:25	72					Clear	24
24	7:31	68	7:10	70					Clear	14
25	7:31	74	8:18	69					Clear	19
26	7:31	68							Clear	15
27	7:30	64	6:40	70					Clear	16
28	7:30	62							Breeze	11
29	7:30	74	Poor flight						Clear	10
30	7:30	65	Poor flight						Clear	3
July 1	7:29	74	Poor flight						Clear	11
2	7:29	84	Poor flight						Clear	43†
3	7:29	72	Poor flight						Clear	7
4	7:29	82	Poor flight						Clear	8
5	7:29	63							Fog	2
6	7:29	62							Fog	1
7	7:29	57							Fog	0
8	7:29	59							Fog	0
9	7:28	56							Fog	0
10	7:28	56							Fog	1
11	7:28	61	7:00	66			7:22	62	Clear	5
12	7:28	63	6:55	66			6:55	66	Clear	6
13	7:28	61	6:35	65	6:40	65	6:40	65	Breeze	2
14	7:28	69	6:50	73	7:20	69	8:20	63	Clear	8
15	7:27	70	7:18	71	7:38	69	8:20	65	Clear	6
16	7:27	65	6:40	71	7:20	66	8:18	61	Fog-wind	11
17	7:27	58	6:05	70	6:45	62	7:35	58	Clear	6
18	7:27	65	7:10	69	7:25	65	8:20	60	Clear	10
19	7:26	68	7:15	70	7:28	68	8:35	60	Clear	14
20	7:26	64	7:05	68	7:37	63	8:05	59	Clear	14
21	7:25	64	7:06	67	7:30	64	8:25	60	Clear	15
22	7:25	70	7:27	70	8:05	64	8:40	61	Clear	14
23	7:24	66	6:15	77	7:20	66	8:16	62	Clear	15

†On these nights but few moth were observed in the pans by 9 P.M. but the following morning a decided increase in numbers was noted.

TABLE (*continued*)

Date	Sunset Time	Sunset Temp. F	First Moth Time	First Moth Temp. F	Maximum Time	Maximum Temp. F	Last Moth Time	Last Moth Temp. F	Weather	Bait Trap Catch
July 24	7:23	70	7:20	70	7:50	67	8:50	60	Clear	19
25	7:22	66	7:15	68	7:55	62	8:20	60	Clear	20
26	7:21	65	6:50	71	7:26	64	7:58	60	Clear	11
27	7:20	59							Fog-wind	0
28	7:20	61	6:05	68	6:43	65	8:00	59	Fog-wind	8
29	7:19	63	6:28	68	7:03	66	8:00	60	Wind	4
30	7:18	64	6:05	70	7:58	61	8:18	59	Clear	11
31	7:18	62	6:18	67	6:53	64	8:06	58	Clear	9
Aug. 1	7:17	63	6:15	68	7:30	62	8:16	59	Clear	18
2	7:15	67	6:03	76	7:14	68	8:42	59	Clear	16
3	7:13	70	6:32	77	7:52	66	8:40	60	Clear	28
4	7:12	68	6:38	71	7:28	65	8:41	59	Clear	32
5	7:11	64	6:28	69	7:06	66	8:00	60	Breeze	17
6	7:10	60	6:12	69	6:30	65	7:42	57	Fog-wind	7
7	7:09	59	5:55	67	6:24	64	7:42	56	Breeze	11
8	7:07	60	6:05	68			7:44	57	Fog-wind	3
9	7:05	59	5:42	67	6:28	61	7:40	57	Fog-wind	5
10	7:04	59	5:45	63	6:28	60	7:35	58	Fog-wind	19
11	7:03	59	6:12	64	6:30	61	7:33	58	Breeze	11
12	7:02	64	6:22	68	7:00	64	7:48	60	Clear	14
13	7:01	70	7:00	70	7:06	68	8:33	62	Clear	44
14	7:00	70	6:40	72			8:02	62	Clear	29
15	6:58	60	6:14	65	6:34	63	6:48	62	Breeze	5
16	6:57	57	5:50	63	6:15	60	6:50	57	Breeze	1
17	6:54	60	5:48	67	6:15	64	7:18	58	Breeze	4
18	6:52	66	6:35	68	7:04	65	7:55	60	Clear	17
19	6:51	73	6:48	73	7:40	65	8:05	62	Clear	30
20	6:49	60	6:34	62			6:34	62	Breeze	1
21	6:47	62	6:20	64	6:24	64	7:04	61	Breeze	6
22	6:46	69	6:16	73	7:20	65	7:38	64	Clear	28
23	6:44	64	5:53	68	7:20	62	7:45	61	Clouds	6
24	6:42	64	6:15	68	6:50	63	6:52	62	Breeze	1
25	6:41	61	6:10	65	6:40	62	6:52	60	Clear	8
26	6:40	63	6:15	66	6:40	63	7:01	60	Breeze	3
27	6:38	70	6:10	72	7:30	65	8:06	63	Clear	17
28	6:36	67	6:17	68	7:05	63	7:26	62	Clear	9
29	6:35	69	6:25	70	6:54	66	7:14	65	Breeze	1
30	6:34	72	6:27	72	6:34	66	7:40	64	Clear	13
31	6:32	72	6:28	73	7:34	66	7:34	66	Clear	15
Sept. 1	6:30	74	7:01	71	8:52	66	9:15	62	Clear	25
2	6:30	67							Fog-wind	2
3	6:28	59							Fog-wind	0
4	6:26	58							Fog-wind	1
5	6:24	59							Fog-wind	0
6	6:22	60							Cloudy	1
7	6:20	62	5:31	67	6:26	63	6:55	60	Breeze	0
8	6:21	64	6:20	64	6:53	62	7:19	60	Breeze	2
9	6:20	64							Breeze	1
10	6:18	69	5:55	71	6:50	65	7:25	64	Clear	10
11	6:16	66	6:18	66			6:35	64	Breeze	4
12	6:14	69	6:23	69	6:35	67	7:25	61	Clear	11
13	6:12	68	6:30	66	6:50	64	7:09	63	Breeze	5
14	6:10	63							Windy	0
15	6:08	61							Windy	2
Sept. 16	6:07	62							Windy	0
17	6:06	68	7:07	63					Clear	9

TABLE (*concluded*)

Date	Sunset Time	Sunset Temp. F	First Moth Time	First Moth Temp. F	Maximum Time	Maximum Temp. F	Last Moth Time	Last Moth Temp. F	Weather	Bait Trap Catch
Sept. 18	6:06	60							Breeze	10
19	6:04	61							Windy	1
20	6:03	60							Breeze	1
21	6:02	66	5:50	67	6:26	62	6:35	62	Clear	12
22	6:00	64	5:55	64	6:20	62	6:21	61	Cloudy	6
23	5:58	68	5:58	68	6:10	66	6:42	63	Clear	11
24	5:56	64	5:35	67	5:40	66	6:15	63	Wind	1
25	5:54	64	5:32	67			5:53	64	Clear	6
26	5:52	64	5:45	64	5:58	64	6:03	63	Wind	2
27	5:50	58							Windy	2
28	5:48	56							Windy	0
29	5:46	59							Cloudy	0
30	5:44	61							Cloudy	1
Oct. 1	5:42	64	5:33	65	5:58	63	6:33	60	Wind	3
2	5:40	67	5:37	69	6:08	64	6:38	62	Clouds	6
3	5:38	73	6:10	68	6:34	65	6:52	64	Clear	6
4	5:37	73	6:35	69	6:39	69	7:33	64	Cloudy	16
5	5:36	70							Cloud-wind	8
6	5:35	64							Cloud-wind	9
7	5:33	61							Cloud-wind	0
8	5:32	62							Cloud-wind	0
9	5:30	66	6:04	62			6:19	61	Clear	1
10	5:29	66							Breeze	0
11	5:28	69	6:10	66					Breeze	0
12	5:26	69							Breeze	0
13	5:24	74	6:04	68	6:18	66	6:37	64	Clear	2
14	5:23	56							Wind	1
15	5:22	57							Wind	0
16	5:21	58							Wind	0
17	5:20	61	5:01	62			5:03	62	Clear	0
18	5:18	65	5:23	65	5:36	63	5:45	62	Clear	0
19	5:16	69	5:07	70	5:56	64	6:12	62	Clear	12
20	5:14	74	5:35	73	6:03	68	6:14	61	Clear	4
21	5:13	76	6:06	71	6:32	68	6:32	68	Clear	4
22	5:12	75							Cloudy	4
23	5:11	68	5:07	69			5:07	69	Cloudy	0
24	5:10	60							Cloudy	0

FOUR YEARS EXPERIMENTS WITH CHEMICALLY TREATED CODLING MOTH BANDS[1]

By L. F. STEINER[2] and G. E. MARSHALL,[3] *Purdue University Agricultural Experiment Station, Lafayette, Indiana*

ABSTRACT

Beta Naphthol-oil and alpha Naphthylamine-oil-paraffin impregnated corrugated paper bands can be used successfully as a supplementary control for the codling moth in Indiana. The alpha-Naphthylamine combination, developed during four years experiments with numerous chemical treatments, appears under Indiana conditions to be superior to the beta-Naphthol combination in effectiveness, and in attractiveness to codling moth larvae. Both materials almost entirely prevent adult emergence. Emergence never has exceeded two per cent of the larvae captured. After use on the same mature trees for three successive years neither chemical has produced any injury.

The necessity for codling moth control measures which can be applied supplementary to spraying is becoming constantly greater. Banding, to trap the larvae, has been recommended as a supplementary control for many years. To be most effective, banding must be accompanied by the removal of other favorable cocooning places from the trees, such as all loose bark, as well as all surface debris from under them. Investigations in Southern Indiana[4] have shown that where this is done more than half and sometimes as many as 80 per cent of the larvae can be trapped by a good tree band.

The necessity for making frequent examinations to remove larvae before they emerge, since it requires considerable labor and expense during the busy season, has probably been the main factor in discouraging the use of bands.

Several investigators during the past few years have conducted experiments to develop a self-working or automatic band by chemical treatment which would require attention only at the beginning and end of the season. This would eliminate the necessity for the examinations which otherwise must be made at ten to fourteen-day intervals. Considerable success has been obtained.

The beta Naphthol-oil impregnation treatment developed by E. H.

[1]Contribution from the Department of Entomology, Purdue University Agricultural Experiment Station.

[2]Assistant in Entomology 1927–1930.

[3]Assistant in Entomology 1930–1931.

[4]1929, Steiner, L. F., Miscellaneous Codling Moth Studies, Jour. Econ. Ent. Vol. 22, No. 4, pp. 648–654.

Seigler and associates[5] and an alpha Naphthylamine-oil-paraffin combination developed at the Purdue Station[6] are coming into general use in Indiana following experimental tests which for three years have yielded satisfactory results. No evidence of accumulative injury following their continued use on the same trees has been apparent.

Investigations with chemically treated bands were begun by the Purdue University Agricultural Experiment Station early in 1927. Little success attended the first season's efforts. The materials tested, all of which were eliminated from further consideration, were as follows: a highly refined oil of the Kerosene type, the same containing a small percentage of paradichlorobenzene, an oil of the lubricating type used in dormant sprays with a high percentage of paradichlorobenzene incorporated, two summer spray oil emulsions, nicotine sulphate, sodium fluosilicate, Derrisol, and Derrax. These materials were applied full strength to four-inch burlap bands of three thicknesses. Five bands of each type were sprayed with five to ten per cent solutions at two-week intervals following the original treatment. Under these conditions between 50 and 60 per cent control was obtained with the summer spray emulsions and the lubricating oil containing paradichlorobenzene.

Six bands of each, excepting the light oil with paradichlorobenzene and nicotine sulphate, were given only the original treatment. Derrax and the two summer oil emulsions gave the best results but killed only 22 and 20 per cent, respectively, of the larvae cocooning under these bands during the season. Serious injury resulted from the use of the paradichlorobenzene oils.

Field tests with the beta Naphthol-oil bands were begun in 1928. The formula published in mimeographed form in 1928 by the U. S. Bureau of Entomology was utilized. This formula called for a mixture of beta-Naphthol (technical) and red-engine oil, one pound to one and one-half pints. Materials to be treated were impregnated with the chemical by dipping in the hot solution.

Several other materials suggested by Dr. H. R. Kraybill, Indiana State Chemist, were also tested on a small scale, using them in the same manner as beta-Naphthol. These included alpha-Naphthylamine (technical), alpha-Naphthol, P-Nitroanaline, 2-Naphthylamine—1 Sul-

[5]1927, Seigler, Brown, Ackerman and Newcomer. Chemical Treatment of Bands as a Supplemental Control for the Codling Moth. Jour. Econ. Ent., Vol. 20, No. 5, pp. 699–701.

[6]The writers are indebted to Dr. H. R. Kraybill who has offered helpful suggestions and who first suggested testing alpha-Naphthylamine.

phonic Acid, Oil Soluble Black, Malachite Green, and Methylene Blue. All bands were treated in June and permitted to remain on the trees undisturbed until October. External examinations for protruding pupae cases were made at ten-day intervals.

The light 1928 infestation made impossible a thorough test of these materials. In one orchard 125 beta-Naththol bands captured 332 larvae while an equal number of similar but untreated bands captured 405 larvae. In another orchard ten beta-Naphthol bands captured 530 larvae as against 387 for ten untreated corrugated paper bands. Birds removed many from the latter. Adult emergence from the treated bands amounted to less than two per cent.

Of the miscellaneous materials, alpha-Naphthylamine was the only one with any promise. Six bands captured 57 larvae, none of which pupated. This chemical often ends larval activity before the worm can spin its cocoon with the result that many larvae, after shriveling up, fall out of the corrugations in paper bands and so are missed in the count. Alpha-Naphthol bands caused fatal injury to several trees. Alpha-Naphthylamine, which should not be confused with Alpha-Naphthol, although it caused considerable bark discoloration, did not produce any evidence of injury.

Because four-inch single faced corrugated paper bands without chemical treatment consistently trapped more codling moth larvae than other banding materials such as crepe paper, burlap, and tar paper, this material was used with all the chemicals tested. It also permits more ventilation with less possibility of injury to the tree, is cheaper than most materials and can be more thoroughly and quickly impregnated with the beta-Naphthol or alpha-Naphthylamine solution. The four-inch width appears most satisfactory, especially where infestations are moderate to severe, since it has consistently proven more attractive than the two-inch bands.

With corrugated paper bands the impregnation process is simple. Using wire hooks, a roll of the paper cut four inches wide is half submerged, flat side down in the hot chemical-oil solution. If the solutions are hot enough the liquid will foam up through the roll and spread over the top. All air is thus forced out of the corrugations and all surfaces are given a complete coating of the mixture. Setting the roll on its side to dry or turning for a few minutes will help retain more chemical. Too hot a solution will result in too thin a coating. Beta-Naphthol dries or crystallizes quickly while the alpha-Naphthylamine band remains more oily. The drying process should not be retarded by stacking the rolls immediately after treatment or by keeping them too

near the heat. These solutions are inflammable and should be protected from direct flames. A steady hot fire is best.

Experiments were continued in 1929 with alpha-Naphthylamine and beta-Naphthol using the same proportions of oil and chemical as heretofore. However, in one series a lighter paraffin oil was substituted for the heavier oil and two tests were made with alpha-Naphthylamine to which paraffin (Parawax) was added. This formula is as follows:

Alpha-Naphthylamine (technical) ..... 1 lb.
Oil-Paraffin or red engine ..... 1½ pts.
Paraffin ..... ¼ lb.

The addition of paraffin to the alpha-Naphthylamine treatment results in a somewhat less oily band which appears considerably more attractive to codling moth larvae. Although the mortality up to the time of the removal of the bands in October was slightly lessened, no emergence occurred.

Results of 1929 experiments are summarized in Table 1.

TABLE 1. CODLING MOTH LARVAE CAPTURED IN 1929 BY CHEMICALLY IMPREGNATED FOUR-INCH CORRUGATED PAPER BANDS

Orchard	Treatment	Number bands	Number larvae per band	Per cent adult emergence	Per cent dead October
1	Untreated corrugated paper (check)	50	15.7	—	—
	Beta Naphthol-paraffin-oil	50	20.5	0.7	73.2
	Alpha Naphthylamine-paraffin-oil	20	28.2	0.1	70.0
	Alpha Naphthylamine-paraffin-oil plus Parawax	5	36.2	0	43.0
2	Untreated corrugated paper (check)	25	33.2	—	—
	Beta Naphthol-red engine oil	30	68.4	0.7	81.0
	Alpha Naphthylamine-red engine oil	25	65.1	0.2	82.3
	Alpha Naphthylamine-red engine oil plus Parawax	5	89.8	0	76.4

NOTE: Early in September in orchard No. 2, birds began feeding on larvae in the bands. Both treated and untreated bands were covered with a strip of wire screen four inches wide which fit flush with the edges of the band. This had no effect on larval entrance from either above or below and effectively served its purpose of protecting trapped larvae from the birds.

In 1930 more extensive banding experiments were undertaken. Approximately 800 bands were applied, 685 of which were collected at the end of the season and all the larvae counted. Five widely separated orchards were used in the tests. The results are summarized in Table 2.

In all of these orchards except No. 5, the bands were applied before July 15. In orchard No. 5 the bands were applied August 27. This

fact may account for the high larval mortality obtained in this orchard since the bands were freshly treated and had been subjected to but little leaching or drying.

TABLE 2. CODLING MOTH LARVAE CAPTURED IN 1930 BY CHEMICALLY IMPREGNATED BANDS

Orchard	Width and Treatment	Number bands	Number larvae per band	Per cent adult emergence	Per cent dead Oct. 25, 1930
	4-inch Untreated corrugated paper	46	49.7	—	—
1	4-inch Alpha Naphthylamine-oil	44	18.3	0.7	20
	4-inch Beta Naphthol-oil	51	15.6	0.3	46
Light	4-inch Alpha Naphthylamine-oil-Parawax	50	19.3	0.1	47
infes-	2-inch Beta Naphthol-oil	49	37.0	0.6	45
ta-	2-inch Beta Naphthol-oil bands—one below crotch and one 6 inches above ground: Bottom band	47	10.8	0.9	45
tion	Top band	47	23.0	0.9	43
2	4-inch Untreated corrugated paper	28	81.5	—	—
Aban-	4-inch Beta Naphthol-oil	29	79.4	1.4	53
doned	4-inch Alpha-Naphthylamine-oil-Parawax	28	105.5	1.2	46
3	4-inch Beta Naphthol-oil	39	30.3	1.2	—
	4-inch Alpha Naphthylamine-oil-Parawax	42	34.3	1.3	24
	4-inch Untreated combination paper burlap	46	53.0	—	—
4	4-inch Beta Naphthol-oil	25	22.6	0.1	43
	4-inch Ortho-phenylphenate, half strength	22	17.0	0.7	16
	4-inch Ortho-phenylphenate, full strength	22	23.0	0.9	6
	4-inch Untreated combination paper burlap	10	58.7	—	—
5	4-inch Ortho-phenyphenol dissolved in Orthoparadichlorobenzene	10	56.5	0	28
Heavy	4-inch Ortho-phenylphenate, full strength	10	52.3	—	16
infesta-	4-inch Ortho-phenylphenate, half strength	10	54.4	—	9
tion	4-inch Beta Naphthol-oil	10	58.5	0	55
	4-inch Alpha Naphthylamine-oil-Parawax	10	84.6	—	76
	4-inch Alpha Naphthylamine-oil	10	106.0	0	85

NOTE: The oil used with beta-Naphthol and alpha-Naphthylamine, in the above tests, was Diamond paraffin. In orchards 1, 2 and 3 the chemical treatments were applied to corrugated paper. In orchards 4 and 5 the banding material used was a combination burlap and paper held together with a tar binder.

In orchards Nos. 2 and 3, bird activity was considerable and in No. 3 the larval kill could not be determined with certainty as a result of birds picking the worms from the bands. In both of these orchards screen wire strips were put over the bands but these did not offer the protection they did in 1929.

In orchards Nos. 2 and 4, chickens, birds, or mammals ate some of the larvae and tore off many of the check bands. Bands such as ortho-phenylphenate and ortho-phenylphenol which do not have some oily

carrier for the chemical, get dry and brittle when subjected to leaching and lose the killing agent rapidly.

In 1929 the bands were applied during the latter part of June. A high mortality resulted before the bands were removed in October. In 1930 the bands were not applied until in July yet the mortality was less than during the previous season. While weather conditions and variations in the amount of chemical deposited on the band during treatment affect mortality, the low percentage of kill obtained in 1930 was undoubtedly due to the unusually large third brood of worms. A large portion of the larvae entered the bands only a few weeks before they were examined late in October.

Climatic conditions in Indiana favor the successful use of chemical bands of the alpha-Naphthylamine or beta-Naphthol type. The rainfall is usually not sufficient to wash too much chemical from the bands, nor are the normal summer temperatures high enough to cause excessive drying and flaking of the killing agent. The adult emergence from bands applied in June or July was negligible each season. On September 1, 1928, 100 healthy larvae were allowed to cocoon in beta-Naphthol and alpha-Naphthylamine bands that had been on the trees since August 1. At the end of four weeks the mortality was 68.6 per cent and 90.4 per cent respectively in these two types of bands.

While a material that will completely prevent adult emergence during the season is needed, it is not necessary that 100 per cent mortality of larvae be obtained if the bands are destroyed during the winter months when the rough bark is removed from the trees.

Both alpha-Naphthylamine and beta-Naphthol bands have been used on the same mature trees for three successive seasons with no apparent injury. The results were so conclusive that these chemical bands were recommended to Indiana fruit growers as a supplementary control for the codling moth[7]. Until further investigations relative to the effects following their use on smooth barked or young trees can be studied, it would appear advisable to refrain from applying them to any except mature trees.

[7]1931, Marshall, G. E. Preparation and Use of Chemically Treated Bands for Codling Moth Control, Cir. 180, Purdue Univ. Agr. Exp. Sta., 4 pp., 4 figs.

INSECTICIDAL CONTROL OF THE EUROPEAN CORN BORER: THE PROBLEMS INVOLVED AND SOME EXPERIMENTAL RESULTS

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ABSTRACT

The writers investigated the feasibility of employing insecticidal sprays as a means of controlling the European corn borer during the early phase of an infestation before the insect adopts the tunnelling habit. The more important problems encountered in the use of insecticides for such a purpose included; timing of applications due to variation in the period of oviposition, maintenance of a spray cover in important feeding areas such as interfoliar spaces, and application to tall varieties of late maturing corn infested by the second brood in the two-generation area. Laboratory and field tests of insecticidal agents indicated that a suspension of acid lead arsenate in one-per cent paraffin oil emulsion was the most useful. The value of such a combination is attributed to depression of the surface tension of the material which leads to further penetration of lead arsenate into interfoliar spaces where the insect habitually feeds during early instars.

Laboratory and field investigations[1] dealing with the use of insecticides as a means of reducing commercial losses from infestation by the European corn borer (*Pyrausta nubilalis* Hübn.) were conducted during 1927, 1928, and 1929 at Arlington, Mass., and Toledo, Ohio.[2] The studies have revealed certain habits peculiar to this species which tend to reduce the effectiveness of insecticides, the lethal capacities of which are generally rated as high. A discussion of these habits in their relation to insecticidal treatment will serve to delimit the problems presented for solution in the development of a spray program effective against this insect.

TREND OF THE INVESTIGATIONS

The objective of this project was to determine whether or not it is possible to provide the individual corn producer with a remedy that will reduce indirect borer injury due to tunneling and at the same time will afford protection to the ear. This viewpoint was adopted in organizing a program at the beginning of the season of 1927. Several years'

[1]This investigation has been continued under commercial conditions during the season of 1930 on the U. S. Department of Agriculture demonstration farm at Berkley, Mass. The results of this work will be reported at an early date.

[2]Field investigations were conducted during 1927 in a commercial field at Medford, Mass. During 1928 and 1929 the field plots were laid out on the developmental farm operated by the U. S. Department of Agriculture at Toledo, Ohio, and on the land of the Massachusetts Agricultural Experiment Station at Waltham, Mass.

experience, as reported by Worthley and Caffrey (7),[3] lay behind the program at that time, but since no tangible leads had been indicated, several new lines of investigation were undertaken. Although it has been a policy to leave unconsidered no insecticide that might possibly prove of value, special attention has been devoted to the development of an oil emulsion-arsenical spray. This trend had its inception during the season of 1927, being indicated by data obtained in field experiments conducted at that time.

Methods

The field and laboratory methods have been those usually considered as standard in insecticide practice and investigation. Owing to variability in the distribution of infestation by this insect in the same field, however, replication of plots has been given greater emphasis than usual.

Field Methods.—During this phase of the work the materials were applied by means of 3-gallon, hand-operated, compressed-air sprayers to plots five hills wide and ten hills deep. Data on survival were from ten "taken" hills located in the three central rows of each plot, provision being made to obtain information on the percentage of reduction in population in terms of decrease in stalk and ear infestation, according to the following formula: $\frac{x - y}{x} \times 100 =$ per cent reduction of population, where x is the number of living larvae in the check and y is the number of surviving larvae in the treated lot.

Early in this investigation it was found necessary to provide as carefully for tolerance-test readings as for survival counts. These readings, taken 48 hours and 1 week following each application as well as at harvest, are recorded with respect both to types of injury and to their extent estimated on a basis of 10. Thus the figure 10 represents complete tolerance and zero, complete intolerance. Slight injuries, indicated by such figures as 8 and 9, are checked later in the season by the yield and the height of the treated plants, while relatively severe injuries, represented by such figures as 3, 4, and 5, are interpreted as too severe to warrant the use of the insecticide employed. Injury is estimated and recorded with respect to the nature and extent of areas of spot necrosis, marginal leaf burn, tip burn, blotch areas, petiole burn, necrotic areas on the stem, and color changes (within the greens).

Laboratory Methods.—Early in the development of this project the necessity of testing insecticides under controlled laboratory con-

[3]Italic numbers in parentheses refer to Literature Cited at end of the paper.

ditions became apparent. Routine procedure includes the use of green string beans, lettuce, or strips of fresh corn blade as infested host material placed in lantern-globe or earthen-pot containers, and incubation at 75° F. with 85 per cent relative humidity.

Although many of the tests in the work with oil emulsions were made with commercial oils, stock emulsions were prepared in the laboratory with an electric mixer, several emulsifiers, including sodium and potassium oleates, casein, laundry soaps, and triethanolamine oleate, being used. For these tests moths were induced to oviposit on sheets of paper impregnated with high-melting-point paraffin, and squares of this impregnated paper bearing egg masses were pinned to the surface of a section of wallboard. They were then sprayed with a hand atomizer and subsequently the treated egg masses, together with water-sprayed egg masses used as checks, were incubated at 75° F. in an atmosphere of 85 per cent relative humidity. Counts to determine the percentages of eggs destroyed were made when the check eggs had completed hatching.

Problems Encountered

The experience with insecticides reviewed in this paper has served to direct attention to several problems involved in the insecticidal control of the European corn borer.

The Boring Habit.—The boring or tunneling habit of the European corn borer is commonly considered a serious obstacle to the effective use of insecticides against it. If it were possible to kill the insect by means of an application delayed until the production of frass indicated the presence of late larval instars, then control would indeed be simple. But no insecticide within present experience possesses the physical qualities which would enable it to kill a sufficiently high percentage of these larvae to reduce their numbers to a satisfactory extent. However, all the larval instars are not lived in a tunnel. The first and the second as well as many of the third instar larvae live between the rolled leaves and on the tassel buds. In an early publication Caffrey (*1*) discussed this habit as offering a possible opportunity for attacking the larvae by insecticidal means, and more recently the habit has been mentioned by Huber, Neiswander, and Salter (*5, p. 45*) in Ohio and by Hodgson (*4, p. 21*) in Massachusetts.

It is evident that the importance of the boring habit of this insect during early instars has been rather exaggerated in popular conception and that it does not present an insurmountable obstacle to the use of insecticides. On the contrary, the insect may be reached by insecticidal

agents during an egg stage of approximately seven days (*1*); during the first and second larval instars, lasting approximately five days each (*2*); and frequently during a more of less limited period in the third instar (*5*). In fact, this insect lives much longer as an external feeder than does the codling moth (*Carpocapsa pomonella* L.) of the apple. There are, however, other protective agencies which are at present more disconcerting to the entomologist than the boring habit of *P. nubilalis* in its later instars.

INTOLERANCE OF CORN TO INSECTICIDES.—One of the first problems encountered in the field investigations developed from the sensitiveness of corn to the chemical action of insecticides. This is apparently due to the rapidity with which, during the early period of its growth, the corn plant exposes new, and therefore rather tender, foliage tissue. "Burning" in corn resembles a chlorotic condition observed in other cultivated plants, and it changes perceptibly with the variety, stage of development, and prevailing weather. The corn plant often appears to overcome some of the effects of rather severe insecticidal burn, but it is difficult to justify the consequent injury and reduction in yield with the assumption that corn-borer damage would have exceeded in importance the injuries resulting from the insecticide employed.

INFESTATION AND THE GROWTH HABIT OF CORN.—There appears to be little correlation between the seasonal development of the European corn borer and the seasonal development of corn, its most common host. Oviposition does not occur at any particular stage in the development of the plant, and in this respect the relations of the pest to corn as a host differ from those observed in the case of several other boring insects. The explanation of this apparent lack of adaptation may be seen in the operation of several factors: The planting date of corn is variable, the plant is sensitive to soil conditions and cultivation practices, and varieties grown in the same district have different growth habits. It would appear, in considering these factors, that it will be rather difficult definitely to fix application dates in relation to the stage of host development (as in the case with the apple) except in communities where cultural practices are uniform. At present four applications are made during the period when the young corn plant is growing from 1 foot to 4 feet in height, but such a statement is not sufficiently specific.

Another aspect of the problem presented by the growth habit of corn as a host of the European corn borer is found in the manner in which leaves are produced. Corn grows rapidly, strikingly so, and initial infestation occurs at the point where this growth is taking place. It is commonly understood that several internodes are produced in rapid

succession and, since leaves are developed at nodes, the growing plant soon acquires a bunch of leaf blades, or a whorl, in its top. As new leaves are produced, older ones unroll and expand. At this time the leaf blades in the mass are closely appressed, some only at their base although inside blades are rolled up throughout their length, and this formation persists until internodular growth lifts them away from one another. This phase in the growth of the corn plant is usually coincidental with the early instars of the European corn borer in sections where there is a single generation or of the first brood where two occur. Larvae hatching upon the older and lower blades disperse over the plant, and many of them find a strong thigmotactic impulse satisfied when they descend between appressed blades. Dissections have indicated that here they remain until the stem has so extended itself as to allow separation of adjacent leaves. This permits the larva to approach the stalk and the insect to become a borer. During this period the insect has not occupied a position deep in the interfoliar spaces. On the contrary, the caterpillar crawls between two leaves only far enough to satisfy its thigmotactic inclinations. The location of the insect at this time, then, is ideal for all its requirements; it is amply protected from weather and external enemies, the humidity is satisfactorily high, and the leaf surface is not yet hardened. As the leaves grow and the spaces widen, the caterpillar descends and continues feeding. Leaf punctures characteristic of infested corn are made under these circumstances, and therefore not in positions exposed to simple insecticidal agents.

The relation between the effectiveness of control and the process and extent of larval establishment is also important. If the individuals hatching from early or from late egg depositions are subject to high mortality, the period of insecticidal applications can be correspondingly shortened. Furthermore, the general occurrence of dead larvae following insecticidal application is not necessarily an indication of the effectiveness of the material in reducing stalk and ear infestation. Such larvae are not always potential "borers," because the normal chances of the survival of larvae in interfoliar spaces greatly outweigh those of larvae which continue to wander about the plant or take up a makeshift abode elsewhere. This is an important consideration. If an expected mortality of 70 to 80 per cent is characteristic of this insect (*1*), then control work is concerned only with the reduction of that 20 to 30 per cent of the population destined to survive. Advance determination of the proportion of these more fortunate individuals is, of course, precluded, but this is not essential since it is known *where* they will survive.

A satisfactory coverage of the corn plant with an insecticide is maintained with difficulty because of the rapidity with which, in growing, this plant exposes new, untreated leaf surface. A spray or a dust applied thoroughly enough at one time to cover a corn plant is in a few days pushed outward and extensive areas of new, unsprayed leaf-blade surface are exposed. These new areas are at the openings of interfoliar spaces, and into them the first-instar larvae, because of their normal tropic reactions, habitually crawl. The most vulnerable areas on the plant are then left without protection until a subsequent application has been made. This is precisely what happens when an application is made of a stomach poison the surface tension of which is high, such as aqueous suspensions of acid lead arsenate.

It is obvious from the foregoing that two problems must be met in connection with the application of insecticides to a plant such as corn: Treatments will be given to plants in widely differing stages of their development; and an effective insecticide must be capable either of destroying the insect before it gains the shelter of interfoliar spaces or of protecting those spaces against successful invasion by first-instar larvae.

Application Methods.—The height of the mature corn plant introduces certain difficulties in applying insecticides against the European corn borer. This is true principally for late-crop corn in a two-generation area. It should be clearly understood, however, that in areas producing sweet corn for the early market infestation occurs when the height of corn is less than the 30 or more inches of clearance afforded by sprayers now being manufactured. Mechanical facilities are available for treating corn in any stage of its development, and information covering their practicability will be reported when field tests now under way are concluded.

Limitations Involving Livestock.—The use of corn as silage and the practice of "feeding out" green cornstalks to livestock introduce a minor problem in insecticide practice. Obviously, only a highly volatile material could be employed under such circumstances. Under eastern conditions, however, corn used for ensilage is usually harvested before it becomes damaged sufficiently to warrant the use of insecticides under normal conditions, and we are inclined to dismiss casual "feeding out" of green stalks as being of little importance as a phase of the corn-producing industry.

Timing the Applications.—Another important problem arises in connection with the extended oviposition period which is characteristic of this insect. Hibernation of the larvae occurs under such a wide

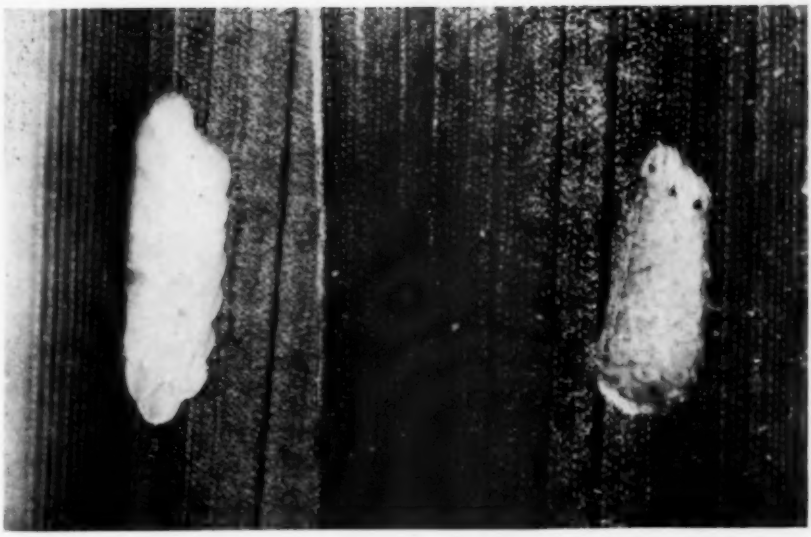
variety of circumstances that emergence of the moths is greatly affected by climatic factors. Caffrey's studies (*1*) indicate that the oviposition periods in the two-generation area may, in the locality of Arlington, Mass., extend approximately as follows: first brood, May 25 to July 25; second brood, July 25 to September 15. In the single-generation area of western New York the period may extend approximately from June 20 to August 5. Naturally there is a comparatively short period, which may be called a peak, when the greatest number of eggs are deposited. There is, however, in the two-generation area a tendency to develop a single generation. The single-generation forms are more prevalent in some years than in others, their abundance apparently being determined by climatic conditions. In some years this leads to prolongation of the period of most active oviposition and causes the occurrence of additional deposition peaks. Although the period during which insecticides must be applied is thereby lengthened, this is not so important as the problem of correctly timing the applications. There is reason to assume that the difficulty of establishing the most effective application dates will be obviated as biological information is accumulated, but at present it is inexpedient to state for the use of the commercial grower just when the first application should be made.

Experimental Results

During the period 1927 to 1929, inclusive, the major effort in this investigation was concerned with tests to determine the relative effectiveness of various insecticides. Many small field plots were employed in this phase of the work. The results obtained and their interpretation are reviewed in the following paragraphs.

Experience With Acid Lead Arsenate.—One of the first objectives in the season of 1927 was to determine why, during the preceding years of this investigation (*7*), acid lead arsenate had failed to give satisfactory reduction of the infestation in field plots. Although a large number of arsenical applications had been made in quantities quite adequate for the purpose, satisfactory control had not been obtained. It was believed that an explanation of this failure might throw some light upon the entire problem of control by means of insecticides.

The program of 1927 was also organized to determine whether or not control could be effected if all the foliage were completely covered with insecticides during the entire period of external feeding by the young borers. Materials were applied in both spray and dust forms in as many as five applications, and "stickers," including several combinations of



Effect of a medium-paraffin-oil emulsion on eggs of the European corn borer (*Pyrausta nubilalis* Hübn). The untreated egg mass at the left shows the normal appearance for comparison with the shrunken eggs in the treated mass on the right. (× 7)

the insecticide with casein and with fish-oil soaps, were employed. The applications were thorough enough and were made frequently enough, but satisfactory control was obtained only in a limited number of plots, as shown in Table 1. It should be noted that acid lead arsenate alone gave a rather unsatisfactory reduction of the larval population (41.7 per cent). The addition of casein to increase the adhesiveness of the application enhanced the effect of the lead arsenate only slightly (51.4 per cent reduction). The use of fish-oil soap increased the effectiveness of lead arsenate 12.9 per cent, and when paraffin oil was substituted for the "sticker" there was a 30.6 per cent increase in effectiveness. "Coated" lead arsenate did not show promise of being useful (22.2 per cent reduction), and when casein was added to it the results were no better.

Work With Oil Emulsions.—After the first field-plot experience with adhesives in 1927, it was apparent that, owing to the growth characteristics of the corn plant, the ordinary lead-arsenate spray would not meet the requirements. There were indications, however, that an oil possessing a comparatively low evaporation rate might be valuable as a supplementary component of a lead-arsenate spray. Thus, the data for plot 5 in Table 1 show that the control value of an arsenical was increased when the arsenical was applied as a suspension in an oil emulsion, and for this reason it was considered prudent to study in greater detail the possibilities of the combination. Accordingly, during the season of 1928 special attention was devoted to a study of the value of various types of oil emulsions, principally as a vehicle for acid lead arsenate. These emulsions were also tested for their relative effectiveness in destroying the eggs of the corn borer and their relative freedom from burning effects on the plant. This phase of the investigation was continued through the season of 1930, although it appeared that suitable oil emulsions had been selected in 1928.

The value of various oil emulsions as egg destroyers in corn-borer control has been demonstrated both in the laboratory and in the field during these experiments. With most of the oils investigated it has been established (Table 2) that, if spray particles make sufficient contact with an egg mass, death usually results within 24 hours. Under field conditions treated egg masses have been observed to become brown and very much shriveled, and later to separate from the leaf surface and drop off. Their general appearance is illustrated on Plate 48.

The oils show rather high effectiveness when employed under laboratory conditions, as indicated in Table 2. Their usefulness in this capacity is best illustrated, however, in a comparison with the data obtained

TABLE 1. TREATMENT AND SURVIVAL SUMMARY OF ARSENICAL INSECTICIDE PLOTS, ARLINGTON, MASS., 1927 (5 APPLICATIONS TO EACH PLOT)

Plot No.	Material	Concentration	Stalk Infestation: Total Number of Stalks Infested	Stalk Infestation: Number of Punctures[1]	Stalk Infestation: Number of Tunnels	Ear Infestation: Total Number of Ears Infested	Ear Infestation: Number of Punctures[1]	Ear Infestation: Number of Tunnels	Ear Infestation: Total Number of Borers	Tunnel Reduction[2]	Larval Reduction[2]
		Lbs. to 50 gals.								*Per cent*	*Per cent*
2	Lead arsenate.....	2	76	99	68	53	14	9	42	46.8	41.7
4	Lead arsenate.....	2	105	81	64	55	12	6	35	51.6	51.4
	Casein.....	2									
5	Lead arsenate.....	2	79	50	25	41	5	2	20	81.4	72.2
	Paraffin oil.....2	per cent by volume									
7	Lead arsenate.....	2	88	63	43	53	9	3	33	68.2	54.2
	Potassium fish-oil soap..	2									
15	"Coated" lead arsenate..	4	106	109	81	50	29	13	56	35.0	22.2
12	"Coated" lead arsenate..	4	113	153	112	49	23	14	65	12.8	9.7
	Casein.....	2									
	No treatment, average of check plots.....		101	160	129	55.5	20.5	15.5	72	0.0	0.0

[1]An indenture less than one inch in depth.
[2]Computed as described under "Methods".

TABLE 2. THE EFFECTIVENESS OF VARIOUS INSECTICIDES AS EGG DESTROYERS AS SHOWN BY LABORATORY TESTS

Sample No.	Material	Concentration[1]	Dead Larvae	Larval Reduction[2]	Emulsifier
		Per cent	*Per cent*	*Per cent*	
1	Heavy paraffin oil[3]	2.0	100.0	100.0	Sodium fatty-acid soap
2	Medium paraffin oil[4]	1.0	100.0	100.0	Triethanelamine oleate
3	Medium paraffin oil[5, 6]	1.25	100.0	100.0	Unknown[6]
4	Light paraffin oil[6]	1.0[7]	100.0	100.0	Unknown[6]
5	Kerosene	2.0	100.0	100.0	Sodium fatty-acid soap
6	Turpentine	2.0	19.6	16.1	Sodium fatty-acid soap
7	Benzine	2.0	63.7	61.2	Sodium fatty-acid soap
8	Miscible asphalt oil[6]	2.0[7]	100.0	100.0	Unknown[6]
9	Corn oil	1.0	56.0	42.2	Sodium fatty-acid soap
10	Fish oil[6]	1.15	70.0	69.0	Potassium fatty-acid soap
11	Creosote oil	2.0	88.8	83.2	Sodium fatty-acid soap
12	Pyrethrum soap (48 per cent)[6]	3.0	90.7	89.6	
13	Pyrethrum soap (33 per cent)[6]	0.6	46.2	25.0	
14	Pyrethrum soap (23 per cent)[6]	0.5	55.0	55.0	
15	Nicotine[6]	0.1	67.3	67.3	
16	Colloidal lead arsenate	2.0	25.0	25.0	
17	Sodium fatty-acid soap	4.0	42.2	35.6	
18	Diethyl carbonate[8]	2.0[7]	56.7	51.9	

[1]Concentration of active agent unless otherwise noted.
[2]Computed as described under "Methods".
[3]Saybolt viscosity at 100°F., 175 seconds; residue unsulphonated, 96.0 per cent.
[4]Saybolt viscosity at 100°F., 80 to 85 seconds; residue unsulphonated, 98.0 per cent.
[5]Viscosity not determined; residue unsulphonated, 96.0 per cent.
[6]Proprietary compound.
[7]Concentration of proprietary compound.
[8]Proprietary compound consisting mainly of diethyl carbonate.

from tests made with nicotine and pyrethrum extracts. Neither of these preparations, even in strong concentrations, compares favorably with the oil emulsions. The tests were conducted, however, in a conditioned atmosphere of approximately 85 per cent relative humidity, which is advantageous to the insect and favorable to an oil emulsion.

The values of the oil emulsions under conditions prevailing in the field are summarized in Table 3. As previously stated, the primary purpose was to determine what oil possessed the most suitable characteristics for its combination with lead arsenate. It was believed that an oil emulsion was required because not only would it have a satisfactory effect in destroying the eggs, but also it would act as a surface-tension depressant. Obviously, however, danger to the corn plant from burning must be kept at a minimum, and it will be noted in Table 3 that this precludes the use of the more toxic oils derived from crude asphalt as well as the heavier oils (including corn oil). The light paraffin oils appeared to be lost during periods of rainfall, they evaporated too rapidly, and their use did not result in the control expected.

TABLE 3. COMPARATIVE EFFECTIVENESS OF OIL PREPARATIONS IN FIELD PLOTS

Sample No.	Kind of Oil[1]	Concentration[2] *Per cent*	Number of Plots	Average Larval Reduction[3] *Per cent*	Tolerance of Plant[3]
1	Heavy paraffin	2.0	1	27.6	9.0
3	Medium paraffin[4]	1.25	3	38.3	9.9
4	Light paraffin[4]	1.25	2	60.8	9.9
8	Miscible asphalt[4]	2.0[5]	3	37.7	7.0
20	Oxidized[4]	2.0[5]	1	35.5	8.5
10	Fish[4]	1.15	3	22.9	9.0
9	Corn	2.0	3	33.0	9.0

[1]Some physical characteristics are given in Table 2.
[2]Concentration of active agent unless otherwise noted.
[3]Estimated as described under "Methods."
[4]Proprietary compound.
[5]Concentration of proprietary compound.

An oxidized oil was tested during the season of 1929. The value of this material as an egg destroyer was found to be sufficient, but the reaction of the plant was unsatisfactory. The field performance of medium paraffin oils has been of such uniform effectiveness, unattended by danger of excessive burning, as to indicate that this is the type of oil sought. Of course, the phrase "medium paraffin oil" means little as indicated in deOng's discussion of specifications for petroleum oils to be used on plants (*2*), and a more complete technical description of these oils, such as that employed by Gill (*3*), might have been more satisactory. The important objective here, however, was to find a suitable

oil for use on corn, and it appears from field experience with oil emulsions that the most satisfactory of these preparations have been derived from rather highly refined paraffin oils the physical properties of which are approximately as follows:

Specific gravity..... 0.8
Unsulphonated residue.....95 per cent or higher
Viscosity at 100°F.....70 to 85 seconds, Saybolt

This should be compared with the findings of the Western Coöperative Oil Spray Project (*6*).

Performance of Oil-arsenical Sprays During 1929.—The 1929 field-plot program was organized to determine the relative insecticidal effectiveness of several of the more promising spray materials, including the oil emulsion-lead arsenate combination and several of the impregnated oils. It was also necessary to confirm the comparative tests that constituted the major portion of the field program of 1928. Field plots were laid off and planted with Golden Bantam sweet corn at Waltham, Mass., and with Burr Leaming dent corn at Toledo, Ohio. The weather conditions prevailing during the season were thought to have been unusually favorable for insecticidal control in that drought retarded plant growth and the insecticides accumulated on the plant surfaces.

Tables 4 and 5 summarize the field-plot tests of toxicity and tolerance conducted during 1929. It should be noted that these tests confirm those of 1928 as to the performance of several of the oils. The heavier corn-oil emulsion fails in its purpose as an insecticide and the same may be said of the heavier white oils.

Very light concentrations of creosote and mercuric iodide in 1 per cent emulsions were found to be unsatisfactory insecticides in the field, although in laboratory experiments they were very effective both as egg destroyers and as larvicides. The actual performance of these emulsions is not indicated in the survival data of Table 4. The plants were injured to such an extent that, owing to weakened stems, they became prostrate, and the softened, necrotic areas of the plant afforded increased opportunity for reinfestation by larvae from the ground.

An oil derived from an asphalt base was employed to determine the possibility of advantage in a more toxic oil emulsion as a supplement to the lead arsenate. The results do not show that sufficient lethal margin prevails to offset the accompanying injury. In the plots at Waltham, Mass., an oxidized oil impregnated with free nicotine, and also with

pyrethrum, showed no superiority over dilute soap solutions of the same materials.

TABLE 4. TREATMENT AND SURVIVAL SUMMARY, ARSENICAL INSECTICIDE PLOTS, WALTHAM, MASS., 1929

Sample No.	Material[1], [2]	Concentration[3]	Average Number of Borers per Hill	Larval Reduction[4]	Tolerance of Plant[4]
		Per cent		*Per cent*	
A-3	Acid lead arsenate	2 lbs. to 50 gals.	1.4	92.7	9.5
O-3	Medium-paraffin-oil emulsion	2.0			
M-9	Nicotine in 0.25 per cent soap	1.0	3.6	81.3	10.0
P-12	Pyrethrum in 0.25 per cent soap	0.6	5.7	70.3	10.0
O-9	Corn-oil emulsion	2.0	7.7	59.9	9.9
P-12	Pyrethrum	1.0	8.6	55.2	8.5
O-20	Miscible oxidized oil	1.0			
M-15	Nicotine	0.12	9.1	52.6	8.5
M-20	Miscible oxidized oil	1.0			
M-43	Cresol in 0.3 per cent soap[5]	0.03	9.8	49.0	1.0
O-3	Medium-paraffin-oil emulsion	2.0	11.6	39.6	9.9
O-20	Miscible oxidized oil[5]	2.0	12.4	35.4	8.5
O-1	Heavy-paraffin-oil emulsion	2.0	13.9	27.6	9.0
M-44	Mercuric iodide	0.01	15.5	19.3	6.0
O-3	Medium-paraffin-oil emulsion	1.0			
M-27	Cresol emulsion[5]	6.0[6]	25.0	0.0	2.0
	Average of check plots		19.2	0.0	10.0

[1]Some physical characteristics are given in Table 2.
[2]Sodium fatty-acid soap emulsifier unless otherwise noted.
[3]Concentration of active agent unless otherwise noted.
[4]Estimated as described under "Methods".
[5]Proprietary compound.
[6]Concentration of proprietary compound.

The insecticidal control obtained in both the Waltham and the Toledo field plots during 1929, as shown in Tables 4 and 5, indicates that an oil emulsion-lead arsenate spray is capable of satisfactorily reducing a heavy infestation of the European corn borer in either sweet corn or dent corn. The major part of the reduction in oil emulsion-lead arsenate plots during 1929 was attributable to two of the applications, and less than four applications, correctly timed, would have been sufficient to afford satisfactory control. The lethal margin of this combination over other arsenicals may be due to the combined value of the egg-destroying capacity of the oil plus the larvicidal action of the arsenical, or to the depressed surface tension of the vehicle. It has already been pointed out that under field conditions the oil emulsions show an appreciable value as egg destroyers, but there appears to be little doubt that the higher efficiency of the oil-arsenical depends upon its physical capacity to spread. That is, the oil emulsion so reduces the interfacial resistance of appressed corn leaves and the surface tension of the lead-arsenate suspension as to induce continued penetration of this material into the

interfoliar spaces, where the insect habitually feeds during early instars. This is substantiated by the presence of lead arsenate when a 1 per cent oil emulsion is employed as a vehicle for the material.

TABLE 5. TREATMENT AND SURVIVAL SUMMARY, ARSENICAL INSECTICIDE PLOTS, TOLEDO, OHIO, 1929

Plot No.	Petroleum Supplement	Emulsified Oil	Dates of Application	Average Number of Larvae per Hill[1]	Larval Reduction[2]	Tolerance of Plant[3]
		Per cent	July		*Per cent*	
Acid Lead Arsenate at Rate of 2 Pounds per 50 Gallons						
2	Miscible asphalt[4]	0.2, 0.2, 1.0, 0.25	1, 8, 12, 16	3.2	68.6	5.5
15	Miscible asphalt[4]	0.2, 1.0	2, 12	8.8	3.3	5.0
22	Miscible asphalt[4]	0.2 1.0	2, 12	1.6	82.5	3.5
24	Miscible asphalt[4]	0.2, 1.0	8, 12	1.1	88.0	8.8
13	Miscible asphalt[4]	0.2, 0.2, 1.0, 0.25	2, 8, 12, 16	5.2	45.8	9.0
18	Medium paraffin[5]	0.2, 0.2, 1.0, 0.25	2, 8, 12, 16	0.7	92.3	9.4
23	Medium paraffin[5]	0.2, 1.0, 0.25	8, 12, 16	1.2	86.8	9.5
25	Medium paraffin[5]	0.2, 0.25	8, 16	2.5	72.5	9.5
27	Medium paraffin[5]	1.0, 0.25	11, 16	1.6	82.4	9.8
28	Medium paraffin[5]	1.0, 0.25	11, 16	3.1	66.0	9.8
26	None		11, 16	6.1	33.0	9.9
No Lead Arsenate						
1	Miscible asphalt	0.2, 0.2, 1.0, 0.25	1, 8, 12, 16	5.6	45.1	6.5
12	Medium paraffin	0.2, 0.2, 1.0, 0.25	1, 8, 12, 16	4.1	57.3	10.0
Check Plots, No Treatment						
7				7.7	—	10.0
11				10.9	—	10.0
14				10.2	—	10.0
17				8.2	—	10.0
21				8.9	—	10.0
33				8.4	—	10.0
43				12.0	—	10.0

[1]Data from ten "taken" hills in each plot.
[2]Computed as described under "Methods," each treated plot being compared with the average of the three nearest check plots.
[3]Estimated as described under "Methods".
[4]Proprietary compound, Sample O-8.
[5]Proprietary compound, Sample O-3.

CONTACT INSECTICIDES.—Although the lead arsenate-oil emulsion combination has occupied much attention as offering the greatest possibilities, it has been considered necessary to determine the lethal effectiveness of various other materials, including many insecticides of the contact type, and these have received serious consideration since the inception of this project.

Worthley and Caffrey (7) reported negative results from the use of nicotine as early as 1919. In 1922 they found a sulphur mixture to be equally ineffective. During the seasons of 1923, 1924, and 1925 they again obtained negative results in the use of nicotine sprays and dusts. Experience with nicotine, both in water solutions and as nicotine-

impregnated oils, during the season of 1929 has been similar. Occasionally a plot has appeared to stand out as indicating satisfactory control, but for the most part the results have not been uniform. Pyrethrum-impregnated oil emulsions have been somewhat more promising, although they also gave inconsistent results.

There appears to be little justification for optimism concerning these materials in their present physical and chemical form. A long period of oviposition makes the use of volatile insecticides impracticable because, although such materials might be effective when employed against a developing infestation, subsequent oviposition would not be taken care of satisfactorily under commercial conditions.

Survival and tolerance data bearing upon the use of contact insecticides taken in field plots at Waltham, Mass., and Toledo, Ohio, during 1928 and 1929 are summarized in Table 6.

TABLE 6. SUMMARY OF FIELD PERFORMANCE OF MISCELLANEOUS CONTACT INSECTICIDES, 1928 AND 1929

Sample No.	Material[1]	Concentration[2]	Larval Reduction[3]	Tolerance of Plant[3]
		Per cent	*Per cent*	
P-12	Pyrethrum soap (48 per cent)[4]	2.0	70.6	10.0
P-13	Pyrethrum soap (23 per cent)[4]	2.0	0.0	4.6
P-14	Pyrethrum soap (33 per cent)[4]	2.0	0.0	10.0
P-1	Pyrethrum soap (30 per cent)[4]	0.6	52.9	9.0
	Medium paraffin oil	1.0		
P-1	Pyrethrum soap (30 per cent)[4]	2.0	55.2	7.5
	Oxidized-oil emulsion	0.25		
M-15	Nicotine (50 per cent)	0.20	29.5	10.0
		1.0	54.0	10.0
		2.0	81.3	10.0
M-14	Nicotine sulphate (40 per cent)	0.5	29.9	10.0
M-15	Nicotine (50 per cent)	0.12	52.6	10.0
	Oxidized-oil emulsion	1.0	74.0	7.0
M-1	Diethyl carbonate	2.0		

[1]All proprietary compounds.
[2]Concentration of proprietary compounds.
[3]Estimated as described under "Methods".
[4]Concentration of pyrethrum soap.

SUMMARY AND CONCLUSIONS

1. The European corn borer usually adopts the stalk-tunneling habit in the second or third larval instar. Previous to this time it is exposed to the action of egg destroyers and larvicides.

2. In the case of the single or of the first generation, during the period when this insect is susceptible to insecticides, the corn plant is in an early stage of its development, and its height does not preclude the application of insecticides by common mechanical methods.

3. An extended oviposition period is characterized by several peaks.

This fact, together with the rapid growth habit of the corn plants during the period of initial infestation, makes necessary from two to four applications in order to insure satisfactory control.

4. Present information indicates that insecticidal practice should be governed by the following assumptions: (a) the occurrence of a dispersal migration immediately following hatching, (b) the success of a small percentage of these larvae in reaching interfoliar spaces between rapidly growing leaves, and (c) survival largely dependent upon success in arriving in these situations in a minimum lapse of time. This introduces the problem of accurately timing the schedule of applications.

5. Laboratory experiments show that eggs of the European corn borer fail to hatch when sprayed with a 1 per cent oil emulsion.

6. Neither acid lead arsenate nor any oil emulsion investigated gave satisfactory control under field conditions when used alone.

7. The most satisfactory oil from the standpoint of tolerance of the corn plant was found to be a highly refined, medium paraffin oil (viscosity 70 to 85 seconds Saybolt at 100°F.).

8. A combination of a lead arsenate suspension in a 1 per cent oil emulsion was found so to reduce the interfacial resistance of appressed leaf blades and to depress the surface tension of the lead-arsenate suspension as to induce penetration of these materials into the interfoliar spaces where the insect habitually feeds during early instars.

9. Insecticides involving the use of nicotine and pyrethrum, as well as several other materials of the contact insecticide type, were not found practical in their present physical form for use against the European corn borer.

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THE SOYBEAN CATERPILLAR IN LOUISIANA

By W. E. HINDS and B. A. OSTERBERGER, *Louisiana Experiment Station Baton Rouge, Louisiana*

ABSTRACT

Anticarsia gemmatilis Hbn. was first reported as a pest on velvet beans in Florida in 1903. It occurred in great abundance on soybeans in Louisiana in 1929 and in less abundance in 1930. Where opportunity is offered, the species demonstrates its preference for soybeans so clearly that the more appropriate common name would be "the soybean caterpillar" instead of "velvet bean caterpillar". Brief notes are given regarding the damage done to soybeans and also regarding some points in life history at Baton Rouge, Louisiana. Insecticidal control is recommended only where necessary to allow the maturity of a desired seed crop and has been found practically possible by dusting with sodium or barium fluosilicates. Natural enemies include numerous species of birds, insect predators and parasites and a fungus disease—*Spicaria prasina* (Maulb.) Saw. The occurrence of this leaf-eating caterpillar should not be considered as a serious obstacle to the further increase of soybean planting in the South.

The occurrence of *Anticarsia gemmatilis* Hbn. as a serious pest on velvet beans in Florida was recorded by Chittenden[1] in 1903. In this report it was stated that the velvet bean crop had been ruined in many localities for several years previous to this year.

Watson in Florida published a considerable report on this insect which he called "The Velvet Bean Caterpillar"[2] in 1916 and from this report particularly it appears that the common name "velvet bean caterpillar" became accepted for *Anticarsia gemmatilis*. From Watson's reports also we conclude that this species is apparently of still more southern origin and that it is not likely to hibernate in the Cotton Belt and therefore may not be expected to occur regularly as a pest on soybeans in this area. The species has occurred again in considerable abundance in southern Louisiana in 1930, and it seems advisable therefore to place on record such additional information as we have at this time.

In Florida it appears that few soybeans were being grown before 1916 and therefore the preference of the species for soybeans was not demonstrated until 1929, when a widespread outbreak of this species occurred in the southern half of Louisiana and extended through the southeastern corner of Texas.

The occurrence of the species in Louisiana with brief notes on life

[1]Chittenden, F. H., U. S. Bur. of Ent. B. 54, p. 77–79 (1903).

[2]Watson, J. R. Control of the Velvet Bean Caterpillar. Florida Exp. Sta. Bul. 130, pp. 45–58; 9 figs. (1916).

history, stages, natural enemies, injuriousness, etc. was recorded by Douglas[3] and Hinds[4] for 1929.

Inquiry among men who have been very familiar with agricultural conditions in south Louisiana for more than ten years past, has brought out the statement that soybeans were completely defoliated in Iberia Parish in 1921, and that occasional light attacks have occurred since that time. In spite of this attack the culture of soybeans has increased steadily in southern Louisiana until now it is estimated that more than 500,000 acres are being grown each year.

It would seem that the very decided preference shown by *Anticarsia gemmatilis* for soybeans when grown side by side with velvet beans, cowpeas and other legume crops should justify a reconsideration of the common name and the adoption of the common name "soybean caterpillar" instead of velvet bean caterpillar. Under food supply conditions enabling them to show evidence as to their food preference, velvet beans are practically untouched until after soybeans have been completely defoliated. Cowpeas, reported as untouched in 1929, were more readily attacked than velvet beans at Baton Rouge in 1930. We have found no evidence of attack on snapbeans or crotalaria varieties at Baton Rouge.

With reference to food plants Watson has recorded velvet beans, kudzu and horse beans. Douglas recorded soybeans with very light feeding on cotton (adjacent to soybeans, evidently) and no feeding found on kudzu, cowpeas or velvet beans at Crowley in 1929. Hinds has recorded soybeans, velvet beans and also stripping of tender locust sprouts (*Robinia pseudacacia*) located far away from any field of soybeans or other cultivated legumes.

To this list at Baton Rouge we can now add cowpeas and coffee weed (*Sesban macrocarpa*). On cowpeas growing near but mixed with soybeans, we found that oviposition was abundant and larvae of all sizes were present. It is certain that complete development may occur on cowpeas and this important legume may suffer more or less damage in future years.

The outbreak of 1930 in Louisiana was not as extensive or serious as that of 1929. The center of early infestation appeared in practically the same section as it occurred in 1921 and 1929; that is, around Jeanerette and New Iberia in the southern part of the State. In this section infestation has now occurred frequently during the past nine years. The

[3]Douglas, W. A. The Velvet Bean Caterpillar as a Pest of Soybeans in Southern Louisiana and Texas. J. Ec. Ent., V. 23, pp. 684–690 (Aug. 1930).

[4]Hinds, W. E. Occurrence of *Anticarsia gemmatilis* as a Soybean Pest in Louisiana in 1929. J. Ec. Ent., V. 23, pp. 711–714, 3 pls. (Aug. 1930).

development here appears to be about 10 days ahead of that occurring at Baton Rouge. The two locations are only about 60 miles apart in a direct line and in a southwesterly-northeasterly direction. Between them, however, lies a very wide stretch of swamp country in the Atchafalaya River drainage area, in which practically no crops are grown. The spread across this swamp area is evidently accomplished by the flight of moths. The drift of light summer air currents is from southwest to northeast.

For the 1930 season Dr. Herbert Spencer stated that a few moths occurred early in the spring and that the first larvae were found on June 13. At that time he considered that these larvae represented the second generation of the species for the season. However, from present information on the limitation of food plants and the unfavorable effects of low minimum temperatures upon larval development, we are inclined to believe that the June larvae represented the first generation, that the scattered larvae of late July and early August were of the second generation and that stripping during September was due to the work of third generation larvae. The final or fourth generation dwindled out through October and disappeared before frost occurred.

During the last week of August larvae could be found readily in some fields, especially of Otootan soybeans, but in most fields no trace of the species could be found in brief examinations.

From the beginning of the third generation, which appeared to have been started early in August, development was rapid and the attack on soybeans increased steadily, with considerable ragging of foliage in a few fields, but no general stripping occurred before the middle of September. Stripping began in 1929 by about the middle of August. During both seasons most of the perforation of foliage which occurred during the early part of the season was due to the feeding work of the bean leaf beetle, *Ceratoma trifurcata*, and other leaf-eating species. This work was confused by many of the growers with that of the soybean caterpillar. Fortunately for the growers in 1930, many of them began to harvest their soybean hay by the last week of July and so had harvested most of their hay crop before the worms became abundant enough to cause any material damage. The damage was confined to fields of late-planted soybeans and to areas where the maturity of seed was desired. Defoliation in 1929 was sufficiently early and general to prevent maturity of seed, but this was not the case in many fields in 1930. Furthermore many of the growers who were growing soybeans for soil-building purposes had already turned under the crop before this damage became noticeable. It is estimated that at least 90% of the soybean

crop in the infested area in 1930 was harvested or buried before the caterpillars did a measurable amount of damage.

Further observations on life history showed that the eggs are laid, as a rule, singly and usually on the undersides of the leaves. Eggs hatched in from three to four days in September. No effort was made to determine the duration of the larval stages during this season, but observations on pupal period are shown in the following table:

PUPAL PERIOD AT BATON ROUGE—1930

Series No.	Location	No. of Stages Pupated	No. of Stages Adults	Pupal Period (Days) Range	Pupal Period (Days) Average	Average Mean Temperature Outside
I	Office	11	10	7–10	8	74.6
II	Insectary	52	45	11–15	13.3	73.0
III	Insectary	61	57	11–16	14	71.7
IV	Insectary	6	6	18–31	22	61.0

During the period of abundant pupation for this generation, it was found that there was a strong tendency to concentrate in loose areas of soil. In some such areas an examination of 100 square inches of surface gave as high as 22 pupae with 8 empty skins and 27 pupae and 3 empty skins. Pupation occurred occasionally on leaves on the plants but usually from practically at the surface under trash to a depth of 5 inches in an area of especially loosened soil. Hard areas showed very few pupae.

The adults from this September generation of larvae emerging during October were abundant in the fields for several weeks, but the development of larvae after this time was checked by various natural causes so that no further stripping of soybeans occurred even where late-planted beans were in thrifty growing condition.

For insecticidal control it seemed advisable to dust certain areas of varieties of beans being grown for seed at Baton Rouge this season. The application was made by means of a Root power duster, by which the five outlets of the machine were concentrated upon 1 row of beans, which were planted in 8 ft. rows. The application of Jungmann's Extra Light sodium fluosilicate without hydrated lime was made at the rate of 15 or 16 pounds per acre and resulted in complete control of the worms with no noticeable burning of foliage except in spots where the machine was stopped for a time and the engine allowed to continue running so that the dosage on the plants was greatly increased at such points. In these areas the maturity of the beans was normal and the seed developed fully.

Tests of applications of Barium fluosilicate, under the trade name of "Dutox", gave excellent control of the worms with no evidence of burning on the soybeans even where it was applied in excessive quantities to tender growing plants. This material promises to be a valuable insecticide for application to tender foliage which is susceptible to arsenical burning.

Among the natural enemies a number of species of birds have been recorded or observed as feeding on the larvae. These include red-winged blackbirds, grackels, bobolinks (rice birds), the green sparrow, English sparrow, killdee and upland plovers, mocking birds, etc.

At least four species of primary parasites have been bred from larvae and pupae of Anticarsia. The most abundant of these were Tachinid flies, especially *Winthemia rufopicta* Bigot (Det. by J. M. Aldrich). These flies were very abundant during the latter part of September and in some collections of Anticarsia larvae as many as 70% bore Trachinid eggs, which were placed usually somewhere on the thorax. *Sarcophaga rapax* Walker (Det. by J. M. Aldrich) was bred frequently but much less commonly than the Winthemia. Two large Ichneumons, *Ephialtes aequalis* (Prov.) and *Ophion bilineatum* Say (Det. by R. A. Cushman) were bred from pupae, but were not abundant. Beside the foregoing, numerous specimens of a small Dipteron, determined for us by Mr. C. T. Green as *Megaselia dyari* Malloch and Megaselia species were bred from dead pupae but it is doubtful whether they are really parasitic in their habits.

Insect predators found included a number of species of Vespoid wasps, *Solenopsis geminata; Calosoma sayi*, in both larval and adult stages; three pentatomids; *Podisus maculiventris, Proxys punctulatus* and *Stiretrus anchorago*.

In both 1929 and 1930 there occurred in September and October a parasitic fungus which has been determined for us as being *Spicaria prasina* (Maulb.) Saw. The name *Botrytis rileyi* is considered as a synomym for this fungus. This fungus was an exceedingly important factor in checking the final fall generation of larvae. It has not been observed by us upon other species of caterpillars, but surely does have some other hosts, or perhaps many other hosts, besides Anticarsia larvae.

From the general standpoint of the desirability of continuing and increasing the culture of soybeans, it would seem that there is really nothing in the occurrence of *Anticarsia gemmatilis* which should be considered as an obstacle to this procedure. It appears that the culture of the crop has continued to increase during the past 10 years with the species present and with only occasional damage. It is quite evident

now that the fairly early planting of the main crop of soybeans will enable the harvesting of hay or turning under of the crops for soil-building with no worm damage whatever and without requirement for insecticidal measures except in small areas where the production of seed is particularly desired. If insecticidal control is needed, it can be secured with the machinery and materials now available.

FIELD TESTS IN TEXAS OF INSECTICIDES FOR CONTROL OF THE COTTON BOLLWORM (*HELIOTHIS OBSOLETA* FAB.)

By R. W. MORELAND, *Bureau of Entomology*, and F. F. BIBBY, *Texas Agricultural Experiment Station*[1]

ABSTRACT

During the past several years damage to cotton from the bollworm has been increasing both in severity and in regularity of occurrence, particularly in the western portion of the Cotton Belt. Owing to numerous changes in production methods control measures developed some years ago do not fit modern conditions. The Bureau of Entomology has been cooperating with the Texas Agricultural Experiment Station in a study of this subject, and the present paper reports the results of three seasons' field experiments in control operations which have shown profitable results from dusting with arsenicals.

The cotton bollworm, *Heliothis obsoleta* Fab., is one of the old cotton pests and has had its share in reducing the crop of the fleecy staple from year to year in the past. Owing to the rapid development of new cotton areas, improved cultural methods, and modern implements that has taken place in the past few years, however, the problem of dealing with this pest may now be considered a new one.

Investigators in the past have given considerable study to the life history, depredations, and control of the bollworm. They found that certain arsenical poisons gave very promising results, and upon this basis made their recommendations for control. Owing to the sporadic occurrence of the worm from year to year, however, these control measures have never been put into practice on a commercial scale. In recent years there has been a more or less steady increase in complaints about this pest. Furthermore, conditions are now such in certain sections of the Cotton Belt that severe damage is almost an annual occurrence, and a degree of loss has been suffered which ap-

[1]Besides the authors, the following men have performed some of the experiments on which this paper is based: J. C. Gaines, S. E. Jones, J. N. Roney, and C. J. Todd, all of the Texas Experiment Station.

parently was never approached in earlier days. On account of these later developments, it has even been suggested by some that the use of certain insecticides may actually increase the bollworm infestation.

The need of additional investigations under modern conditions to supplement the work of earlier investigators has been obvious for some time. At the time the present study was begun a condition existed in the Brazos Bottoms and the adjacent country of central Texas which constituted a serious problem and at the same time gave the most suitable conditions for experimentation. Cooperative investigations by the United States Department of Agriculture and the Texas Experiment Station were therefore started in this district in 1928.

In connection with these studies numerous field-plat tests have been conducted with various insecticides. The purpose of these was twofold. First, to check up on the suggestion that such use of insecticides might under some conditions actually result in an increased infestation; second, to measure the effectiveness of various insecticides applied at different seasons.

The first subject has been thoroughly covered by numerous tests during all three years under conditions of infestation ranging from exceedingly light to very heavy and with all types of application, including the most excessive, extending through the entire season. At no time was there the slightest indication that these applications tended to increase infestation. In fact the results were so directly the opposite that there is quite obviously no need for fear on this score.

The field tests of insecticides for control on which this paper is based have been conducted from 1928 to 1930, inclusive. Counties and localities in Texas where infestations have been heaviest and the necessity for such investigations seemed greatest were selected for these tests. In some instances poor selections were made, as it is not yet possible to predict with any degree of exactness when and where there will be recurrences of severe bollworm infestation. In certain localities, however, prognostication was unnecessary as the experiments were not started until heavy infestation had developed. Such delays in starting the experiments, where they occurred, were unavoidable; nevertheless, in one locality where applications were begun a month late there was a gain of as much as 1,183 pounds of seed cotton to the acre from dusting with an arsenical.

Tests have been conducted in the following counties in Texas: Brazos, Burleson, Bastrop, Williamson, Collin, Dickens and Madison. The soil in these counties, on which the tests were conducted, is as

follows: Brazos County, Miller clay and Yahola silt loam; Burleson County, Miller and Yahola clay and clay loam; Bastrop County, Bastrop fine sandy loam; Williamson County, Houston black clay; Collin County, Houston black clay; Dickens County, Spur clay loam; and Madison County, Trinity clay. The insecticides tested were calcium arsenate, alone and with 2 per cent nicotine; mixtures, both factory and home mixed, containing 75 per cent calcium arsenate and 25 per cent Paris green; and sodium fluosilicate.

Tests of 1928

In 1928 tests were made in Burleson, Williamson, Collin, Bastrop, and Dickens Counties, but the infestation was too light, except in the last two places, to yield reliable data concerning the application of any insecticide as a practical control measure for the cotton bollworm. Experiments were not begun in Bastrop and Dickens Counties until the likelihood of the development of infestation in the other localities had passed. Then only incomplete tests were made. The results indicated that the cotton bollworm might be controlled with an arsenical and that calcium arsenate plus Paris green was the most promising of the dusts tested during 1928. Sodium fluosilicate gave but slight, if any, indication of control.

One of the mixtures used was a factory-made commercial preparation containing 75 per cent calcium arsenate and 25 per cent Paris green. This is designated as "mixture A" to distinguish it from the homemade mixture of the same ingredients.

Tests of 1929

In 1929 experiments were again conducted in Bastrop, Burleson, Collin, Dickens, and Williamson Counties. The following field tests were made: (1) A comparison of calcium arsenate with mixture A, all tested under optimum conditions for maximum control, if possible, by applying them at 5-day intervals from the beginning to the end of the infestation; (2) a comparison of calcium arsenate with mixture A, each applied at 7-day intervals; (3) a comparison of the effectiveness of applications of mixture A deferred for different lengths of time, to determine the optimum time (in regard to the advancement of infestation) to begin applications.

COMPARISON OF CALCIUM ARSENATE WITH MIXTURE A.—In a series of five 3-plat[3] tests in comparing calcium arsenate with mixture A one plat of each test was dusted with calcium arsenate, one with mixture A, and the remaining one left untreated as a check on each of the others. The applications were made at 5-day intervals.

Three of these tests were made at Taylor in Williamson County and the others near Bryan in Burleson County. The infestation was too light in the three tests at Taylor to permit any reliable conclusions as to the relative merits of the arsenicals tested, but in Burleson County the infestation was sufficiently heavy. In one of the tests in Burleson County nine applications, begun July 12 and discontinued August 24, were made on each of the treated plats, and in the other ten applications, from July 10 to August 25. The records for July show that the infestation was kept lower during that month in the plats dusted with calcium arsenate than in those dusted with mixture A but after that time the infestation in the plats dusted with mixture A was constantly lower than in those treated with calcium arsenate. The infestation in all of the treated plats was appreciably lower than in the untreated ones. The plat dusted with mixture A yielded more per acre on each of these tests than did the plats dusted with calcium arsenate. The average of the yields in pounds of seed cotton per acre is as follows:

	Pounds
Untreated plat	673
Calcium arsenate-dusted	1,321
Mixture A	1,386

Besides these comparisons of calcium arsenate with mixture A, there was one 3-plat test in Bastrop County in which each of the arsenicals was applied at 7-day intervals instead of 5-day intervals, at the rate of 7½ pounds per acre for each application from July 10 to September 11, making a total of 10 applications for each of the treated plats. The infestation in these plats was severe enough for a reliable comparison of the insecticides. The yields in pounds of seed cotton per acre were as follows:

[3]By the term "3-plat test" as used in this paper is meant a cut of cotton (usually about 3 acres in size) divided into three measured plats of about equal size and so selected that if all of them were left untreated or were treated alike their yield would be approximately the same per acre. Any variable other than the difference in experimental treatment was thereby minimized. Two of the plats received different treatments, and one was left untreated as a check.

	Pounds
Untreated plat	420
Calcium arsenate- dusted plat	880
Mixture A	776

The chief difference between the results of this test and the preceding ones is that the plat dusted with calcium arsenate yielded more than the one dusted with mixture A.

In two out of three of the above tests the plat dusted with mixture A made a greater gain per acre over its check plat than did the calcium-arsenate plat. The average gain of these two plats dusted with mixture A over the plats treated with calcium arsenate was 65 pounds of seed cotton, while in the third test the plat treated with calcium arsenate made a gain of 104 pounds over the plat treated with mixture A.

Summarizing these three tests, it is seen that the average yield of the untreated check plat was 588 pounds of seed cotton per acre, that of the plats dusted with calcium arsenate 1,174 pounds per acre, and that of the plats dusted with mixture A 1,183 pounds per acre. Thus the two arsenicals showed a difference of only 9 pounds per acre, which is of no significance. The most striking feature is the fact that the poisoned plats yielded approximately double the crop of the unpoisoned plats, the average gain being slightly less than 600 pounds of seed cotton per acre.

Comparison of Sodium Fluosilicate with Calcium Arsenate.—One 3-plat test for comparing sodium fluosilicate with calcium arsenate was made near Bryan in Burleson County. The applications were begun on August 23 and discontinued on September 10, a total of five being made at from 4 to 5 day intervals with an average of about 10 pounds of sodium fluosilicate per acre at each application and 8½ pounds of calcium arsenate per acre per application. The tests were begun too late to be conclusive as to the merits of either of the insecticides. Two broods of bollworms had already come and gone. The form counts, infestation records, and yields did, however, indicate that each of the insecticides produced some control. An increase in yield over that of the untreated plat, which is the ultimate aim of such control work, was made in each of the treated plats. The yield for each of the three plats in pounds of seed cotton per acre was as follows:

	Pounds
Untreated	416
Sodium fluosilicate	571
Calcium arsenate	726

Deferred Applications.—Several tests of deferred applications

were made with the view to determine the proper time, in relation to the advancement of infestation, for beginning applications. Three series of these tests were made in Burleson County, one in Collin County, and one in Williamson County. In three of the tests one plat in each was dusted with mixture A when the first indications of the beginning of an infestation were found. These were treated for maximum control in order to have a plat with which the effectiveness of deferred applications could be compared. The treated plats of this entire series were dusted with mixutre A at the rate of 7 to 8 pounds to the acre at 5-day intervals, applications being continued, after they were once begun, until all probable damage from the bollworm had ceased. The first application on each of the other treated plats of these three tests was deferred until ten days after the plat with which it was to be compared had been treated for maximum control. For the sake of explanation we shall call these tests experiment 1, and each plat that received its first application of mixture A at the beginning of the infestation plat 2 of the same experiment, and each of the other treated plats plat 3. (In our tests we always designate the untreated check as plat 1.) The other two tests we shall designate as experiment 2. In this latter experiment, in one plat of each test (which we shall call plat 2 of experiment 2) the applications were begun 20 days after those on plat 2 of experiment 1. The application on the remaining plat (which we shall call plat 3) of each test was deferred for 33 days after the application on plat 2 of experiment 1, with which it was to be compared.

Regardless of the advancement of the infestation at the time the poison applications were made, our records indicate that some control was obtained in every instance. Below are given the yields of three 3-plat tests, the number of applications, and the dates of beginning and discontinuing them. These yields were all on the same plantation in Burleson County where there was a heavy infestation of three broods of bollworms with such an overlapping that there was but little lull in the infestation from July to September.

The yields in pounds of seed cotton per acre are as follows:

Experiment 1

	Pounds
Plat 1. Untreated check	570
Plat 2. Maximum control, 10 applications of Mixture A from July 10 to August 25	1,637[a]

[a]On account of excessive rains the first week in July, the applications were begun about a week later than had been planned.

Plat 3. Deferred 10 days, 8 applications of Mixture A from July 20 to August 25 1,372

Experiment 2[4]

Plats 1. Untreated checks 276
Plats 2. Deferred 20 days after first application of plat 2, experiment 1; 4 applications of Mixture A from July 30 to August 17 760
Plats 3. Deferred 33 days after first application of plat 2, experiment 1; 2 applications of Mixture A, August 12 to August 17 609

The yields of experiments 1 and 2 are not entirely comparable, as may readily be seen from the fact that the untreated plats in the two experiments varied considerably in yield. Although the advance of infestation in each of the experiments was about the same, the infestation was probably heavier in experiment 2. The tests did indicate, however, that at least partial control can be effected after the infestation is well under way. Plats 3 of experiment 2, on which applications were deferred for 33 days after those on plat 2 of experiment 1 were begun, still yielded with only two applications of the arsenical, 333 pounds of seed cotton to the acre more than did their checks. This is indeed a good gain from two applications of an arsenical and is greater per application by about 60 pounds of seed cotton per acre than that made on the plat treated for maximum control. Nevertheless there is certainly a limit to the time during which applications may be deferred and such gains made, since the coming of frost puts an end to cotton growth for the season. It would not seem advisable to defer applications until the infestation becomes as far advanced as in experiment 2. The length of the growing season, if nothing else, would fix a limit to the time that applications could be deferred, and besides, we all know that the earlier the bolls are matured and the sooner the cotton from them is picked, the less likely they are to meet with adverse conditions. So it behooves us to begin control when the first brood appears instead of waiting until it is well advanced or until another brood has appeared.

Tests of 1930

The experiments of 1930 were conducted in the Trinity River bottom at Midway, Madison County, in fields that had been overflowed and later replanted to cotton about June 10. These fields became severely infested with a July brood of bollworms, and with successive broods fully as severe in August and September.

[4]The yields are the averages of duplicate tests.

Under these conditions, one plat on which applications of the arsenical were begun on August 2 yielded 1,183 pounds of seed cotton to the acre more than did its check. Another plat, on which the applications were deferred 25 days, yielded only 89 pounds of seed cotton to the acre more than did its check.

The complete series of tests showed the average yield of all plats which received the full series of treatments starting August 2 to be 1,135 pounds of seed cotton per acre which was 1,000 pounds more than the average of the checks. When the application was deferred 7 days the increase over the check was 909 pounds, but 11 days' delay reduced the gain to 302 pounds, and 25 days' delay reduced it to 89 pounds. It should be mentioned that these plats poisoned latest set bolls for much more increase than these figures would indicate, but these bolls were so late that they did not have time to open before frost.

Throughout all of these tests a complete record was kept of the activity of all cotton insects on these plats, as there are, of course, several other pests which might be influenced by these poison applications. Fortunately conditions were such that it was possible to eliminate more or less the factor of other insects in the tests reported. Ordinarily the boll weevil would be the most important, but the records show that there could have been no weevil damage in these tests, even on the unpoisoned check plats. Care was taken to avoid areas of heavy weevil infestation. In 1929 the highest square-infestation record on any plat was 47 per cent, and this was late in the season when no commercial damage could be expected from such a degree of activity. In 1930 climatic control of the weevil was so complete that it was never a factor in reducing the yield.

Summary and Conclusions

Infestation by the cotton bollworm is not increased by the application of calcium arsenate or other insecticidal dusts to the cotton. In every plat treated with insecticides in these experiments there was a gain over its check in yield of cotton, whatever the poison used and whether the number of applications was moderate or excessive.

The difference in yield between plats treated with a commercial mixture consisting of 75 per cent of calcium arsenate and 25 per cent of Paris green, and plats treated with calcium arsenate alone, was so small that neither material can yet be regarded as definitely superior to the other. In some tests calcium arsenate gave slightly better results than the commercial mixture whereas in others the reverse was true.

The application of sodium fluosilicate dust to cotton gave but slight if any control of the bollworm in 1928. In 1929 the plat treated with this material yielded more cotton than the untreated plat but not as much as the plat treated with calcium arsenate.

Best results in cotton yield are obtained when the cotton is dusted regularly at proper intervals beginning at the time the first brood of the bollworm appears. In the tests, the longer the first application was deferred, the less was the gain in cotton yield over the check. Although in all the tests there was some gain in yield, regardless of the advancement of the bollworm infestation at the time poison applications were begun, it does not seem advisable to defer applications too long, as the fruit set late in the season is likely to be prevented by frosts from maturing.

A PRELIMINARY REPORT ON LARGE-SCALE BAIT TRAPPING OF THE ORIENTAL FRUIT MOTH[1] IN INDIANA AND GEORGIA

By W. P. YETTER, JR., *Associate Entomologist, and* L. F. STEINER, *Assistant Entomologist, Deciduous Fruit Insect Investigations, U. S. Bureau of Entomology*

ABSTRACT

Two 500-acre bait-trap experiments against the oriental fruit moth (*Laspeyresia molesta* Busch) were initiated in 1930, one at Vincennes, Indiana, and the other at Cornelia, Georgia.

At the former locality a molasses-citral bait failed to give any evidence of control. At Cornelia a peach-juice granulated sugar combination appeared to somewhat reduce the infestation; however, the light infestation and the unusual seasonal conditions apparently so affected the results that they are not convincing. The overwintering brood appeared larger in the baited area at Vincennes and in the unbaited area at Cornelia. A total crop failure in Indiana together with severe drought conditions complicated results.

A large number of other possible bait solutions were tested at each locality. Among 414 solutions tested at Cornelia over 40 proved superior to that used in the large area. The latter was less than 25 per cent as attractive as an ethyl cinnamate medium-brown sugar combination. At Vincennes the most attractive solution was a combination of methyl cinnamate and brown sugar.

At Cornelia 69 and 78 per cent recoveries were made within 5 days, of marked moths released inside a 14-acre experimental block. Ten per cent of a release made in an unbaited peach orchard more than one-fourth mile away was recovered in this small block. The average distance traveled was one-third mile. There is evidence that following emergence many oriental fruit moths travel more than 200 yards before beginning to oviposit. Very few eggs were deposited by moths before their

[1] *Laspeyresia molesta* Busck.

capture. Experiments with released moths indicate that a small baited block containing 1,000 traps or less, if surrounded by unbaited peaches, may draw more moths from the unbaited territory than were naturally present in the orchard baited.

At both Vincennes and Cornelia the small 8 and 14-acre blocks containing experimental solutions averaged, respectively, twelve and five times as many moths per trap as the large 500-acre areas.

During the past ten years, various investigators have made enormous catches of oriental fruit moths with bait traps. The attractive agent was usually a solution of fermenting fruit juices or sugars. Certain essential oils were also tested, sometimes in combination with a granulated-sugar solution or with water alone. These solutions were held in open containers of several types and suspended from peach trees. No appreciable reductions in infestation resulted in the areas baited, probably because the tests were of necessity conducted on a limited scale.

Measures that have been recommended for the control of this pest are entirely inadequate. Theoretically bait trapping should be more effective than results up to now have indicated. Opportunities for investigation along this line are by no means exhausted.

Bait-trapping experiments at Vincennes, Indiana, in 1929[2] resulted in the development of the fruit-jar and screen-lid type of trap and the discovery of several very attractive solutions which continued to catch thousands of moths long after peach harvest.

It was largely due to this work that the Indiana fruit growers and others who became interested were able to get Congress in 1930 to appropriate funds for two large-scale bait-trapping experiments of 500 acres each. Funds were also provided for work with insecticides and parasites. The bait-trapping experiments are being conducted at Vincennes, Indiana,[3] and Cornelia, Georgia.

Since the effectiveness of bait trapping has been of questionable value, it is hoped that the work now being conducted in these two localities will settle the question which has long existed as to whether the use of bait traps on a large scale will give adequate control.

Both Vincennes and Cornelia are peach and apple growing centers. The former is on a slightly rolling rich sandy-loam soil, with a normal rainfall of about 49 inches, and with maximum summer temperatures high. The average elevation is near 450 feet. The crop is frequently

[2]W. P. Yetter, Jr., Journ. Econ. Ent., Vol. 23, No. 1, pp. 85–89, 1930.

[3]The investigations on which this paper are based were conducted at the field laboratories maintained at Vincennes, Indiana, and Cornelia, Georgia, by the U. S. Bureau of Entomology, under the general supervision of Dr. A. L. Quaintance and in cooperatio n with the Purdue University Agricultural Experiment Station and the Georgia State Board of Entomology.

killed by spring frosts. The trees are large. At Cornelia the soil is mostly a clay-loam. The average elevation is approximately 1,600 feet. The country is very rolling, necessitating terracing in the orchards. Trees are small at maturity and are closely planted. Normal precipitation is 57 inches.

Peach and apple orchards adjoin in both localities. Native parasitism is high at Vincennes but almost absent at Cornelia. In both districts the oriental fruit moth is frequently the limiting factor in profitable peach production.

SEASONAL CONDITIONS: Because of their unusual character in 1929 and 1930, season conditions are worthy of mention.

At Vincennes in 1929 it was evident by late fall that the hibernating population was very great. In December, 1929, and January, 1930 unusually low temperatures prevailed. After the cold weather the peach buds were found to be totally destroyed. Examinations of large numbers of overwintering oriental fruit moth larvae in the orchards indicated that from 80 to 100 per cent had been killed. By March 1 it appeared that many of the peach trees were badly injured by the low temperatures. This injury was more in evidence by early summer when the wood in nearly all of the trees began to harden prematurely. This premature hardening of the twigs appeared to hinder oriental fruit moth development as early as July 15. Moths emerging from the wood were dwarfed. Before the end of the month the highest summer temperatures on record had been passed and the area was passing through probably its most severe drought. The deficiency in rainfall up to November 1 was 17.61 inches. Over 6 per cent of the trees in the baited area had died during the summer.

The 1929 infestation at Cornelia was severe. The 1930 infestation, however, developed slowly until in June when it began to increase rapidly until the peak in second-brood adult emergence was reached in early July. The anticipated large increase in twig and fruit infestation following this heavy adult emergence failed to materialize with the result that the light crop escaped with about 6 per cent injury. Apparently high temperatures and low humidity affected egg deposition or hatching. Eggs were almost impossible to find. On August 1 deficiency in normal rainfall amounted to 11.5 inches and by November 1 it had increased to 13.8 inches. While the oriental fruit moth population rapidly decreased after mid-July, the codling moth population even more rapidly increased.

It will be impossible to establish the true value of bait trapping until a wide variety of seasonal conditions have been experienced.

Investigations at Vincennes, Indiana

Personnel: Permanent staff, two; temporary, four field assistants, one of whom acted as foreman of the twelve laborers and three teamsters.

The 500-acre Experiment: Five hundred acres of the peach orchards within 3 miles of Vincennes were selected for baiting. The chief varieties are Elberta and Hale with a few Hiley and Krummel. A total of 30,186 peach trees and 4,851 apple trees were baited. The baited area was divided into 15 main orchards and 31 small scattered blocks of trees. The 35,037 traps required were all of the wide-mouth quart-jar type with a metal rim and a wire screen of one-fourth inch mesh. One trap was used in each tree.

A 10 per cent solution of blackstrap molasses with emulsified citral[4] was used over the entire baited area. The citral was used at the rate of 1 cc. per quart of bait material.

Owing to the late start of the work in the spring, the entire spring brood was missed and most of the peach trees in the baited area were heavily pruned before the traps were put out. Many oriental fruit moth larvae may have been destroyed by this pruning.

Four trucks were used in the work. One was used to supply bait material to the three bait or refilling crews in the orchards; one by the crew who examined the 1,200 record bait traps; one by the crew who examined the leaves and twigs on 464 record twig trees, and one for general use about the entire area. Twelve 7-foot poles were used in hanging the traps in the trees that were rather large. Three closed water tanks with an average capacity of 136 gallons were used as bait tanks. These bait tanks were placed on wagons and hauled about in the orchards. The traps were filled from these tanks and were then placed in the upper third of the tree. Four men with each bait wagon, including the teamster, under ideal conditions could refill on the average about 45 traps per man per hour. The bait material in the traps was thrown out and replaced by fresh bait twice a month. In throwing the old bait material on the ground, care was exercised to see that it was covered up by scraping dirt over it with the foot. This destroys any insects present and also prevents the old bait material from giving off odors which might attract the moths. The traps were refilled ten times during the season.

[4]Beginning July 15, citral emulsified in saponin and water was used as worked out by the Bureau of Chemistry and Soils. Previous to this, 1 cc. of citral was dropped into each trap before the solution of molasses was added.

The most desirable orchards that could be used as checks were located as follows:

1. Unbaited peach trees within one-half mile of baited area.
2. Unbaited peach trees adjacent to unbaited apple trees more than one-half mile from baited area.

The baited area has always been more heavily infested than the unbaited area. The insect has now spread to all parts of the county with the more severe infestation still in the baited area. It is because of this that the use of satisfactory and sufficient check orchards was made impossible.

The 1,200 molasses-citral record traps were examined about four times a week. The only insects removed and recorded were the oriental fruit moths and codling moths.

From June 1 to September 11, eleven examinations of leaves for egg deposition were made and injured twigs on 464 trees were removed and examined. Efforts were made to differentiate between fresh and old injury in order to keep in touch with the progress of the broods. The number of infested twigs found is not a true index of infestation by larvae of the oriental fruit moth, since some of the twigs were infested by the peach twig borer, *Anarsia lineatella* Zeller.

All of the fruits (42,228) on 67 apple trees were sliced to determine the percentage of codling moth and oriental fruit moth larvae present at the time of slicing. Three pickings, each about a week apart, were made at harvest time.

RESULTS: During the season the 199 record traps in the apple trees caught 50 oriental fruit moths while the 1,001 record traps in the peach trees caught 1,240. From these 1,290 moths there were only 310 which were examined for sex and the females for egg content. Out of the 310 moths examined, 72.6 per cent were females. These contained 10,236 eggs, or an average of 45.49 per female. A few were without eggs. The maximum number found in any one moth was 162. It was impossible to determine the exact number of eggs present in all cases since some of the eggs had not developed to the point where they could be recognized.

An estimate of the total number of moths caught during the season, based on captures made by the record traps, would indicate that the 30,186 traps in the peach trees caught 37,400 moths and the 4,851 in the apple trees captured 1,200, making a total of 38,600 moths for the 500-acre area.

Approximately 44 per cent of the record traps in the peach trees failed to trap moths at any time during the season, while 83 per cent

TABLE 1. TWIG INJURY VS. TWIG GROWTH OF PEACH TREES VS. CATCH OF ORIENTAL FRUIT MOTHS IN EACH ORCHARD, VINCENNES, INDIANA, 1930

Orchard	Trees Examined *Number*	Leaves Examined *Number*	Eggs Found *Number*	Twigs on Trees *Number*	Infested Twigs *Number*	Infested Twigs *Per cent*	Twig Growth: Short Twigs *Number*	Twig Growth: Average Length *Cm*	Twig Growth: Long Twigs *Number*	Twig Growth: Average Length *Cm*	Traps Examined *Number*	Moths Trapped *Number*
Baited Orchards[1]												
Kimmell, M. B.	50	110,000	952	77,069	17,068	22.14	5,000	6.11	5,000	17.59	129	198
Kimmell, K.	14	30,800	51	10,991	1,818	16.54	1,400	6.37	1,400	22.51	41	33
Kimmell, S.	17	37,400	235	24,734	7,082	28.63	1,700	6.75	1,700	20.90	36	42
Cushing	24	50,600	299	43,465	5,839	13.43	2,400	6.22	2 400	21.36	44	62
Nesbitt	56	123,200	669	80,383	11,114	13.82	5,600	7.06	5,600	21.29	136	127
Byers	40	88,000	373	72,342	10,174	14.06	4,000	6.78	4,000	20.73	120	58
Riddle	16	35,200	134	17,278	3,083	17.84	1,600	6.30	1,600	20.67	41	33
Boykin	10	22,000	52	8,293	1,175	14.16	1,000	5.65	1,000	17.30	25	19
Teschner	22	48,400	367	32,593	7,982	24.48	2,200	6.19	2,200	20.97	65	93
Dyer-Hiley	24	52,800	323	39,285	6,273	15.96	2,400	6.00	2,400	21.22	68	52
Dyer-Hale	30	66,000	258	50,536	5,018	9.92	3,000	6.89	3,000	20.11	79	111
Dyer-Elberta	56	123,200	616	113,932	12,227	10.73	5,600	5.92	5,600	19.52	136	219
Simpson	30	66,000	340	51,151	11,823	23.11	3,000	7.08	3,000	21.75	81	193
Total	389	853,600	4,669	622,052	100,676	—	38,900	6.46	38,900	20.33	1,001	1,240
Tree Average	—	2,194	12	1,599	259	16.51	100	6.46	100	20.33	—	—
Unbaited Orchards[1]												
Purdue	25	55,000	210	30,078	5,513	18.32	2,500	6.90	2,500	24.13		
Stein	25	55,000	257	64,164	8,844	13.78	2,500	6.01	2,500	21.46		
Buss	25	55,000	204	37,294	4,834	12.96	2,500	5.82	2,500	17.70		
Total	75	165,000	671	131,536	19,191	—	7,500	6.24	7,500	21.10		
Tree Average	—	2,200	8.9	1,754	256	15.02	100	6.24	100	21.10		

[1]Examinations of twigs and record traps made from June 1 to September 11.
Twig measurements made in late September and early October after growth had ceased.

in the apple trees were ineffective. Over 57 per cent of the oriental fruit moths trapped in the record traps in the peach trees were caught in June, 38 per cent in July, 3 per cent in August, and about 1 per cent in September.

Very few oriental fruit moth larvae were found in the apples. Less than one-tenth of 1 per cent of those in the unbaited area contained oriental fruit moth larvae while in the baited area the apples contained less than two-tenths of 1 per cent. The Winesap apples in the unbaited area showed 10.99 per cent worm injury and the Grimes Golden 9.92 per cent. The same varieties in the baited area showed 17.55 and 8.82 per cent worm injury respectively. The worm injury in both the baited and unbaited apples was largely due to the codling moth.

The infestation in the twigs began to decline very rapidly after July 19 in both the baited and unbaited areas. From June 25 to July 1, approximately 3,000 injured twigs were examined for dead fruit moth larvae and none were found. Those present were all alive. From July 31 to August 16 a total of 6,030 injured twigs were examined for dead larvae. There were 123 dead and 14 live oriental fruit moth larvae and 5 dead and 93 live peach twig borer larvae. In other words, 89.7 per cent of the oriental fruit moth and 5.2 per cent of the peach twig borer larvae found were dead. Just why so many oriental fruit moth larvae were dead and so many peach twig borer larvae alive is not clearly understood. Possibly the peach twig borer larvae were able to withstand the unusual weather conditions better than the oriental fruit moth larvae.

In Table 1 it will be noted that the percentage of infested peach twigs in the baited and unbaited areas was about the same. The traps apparently did not reduce the infestation in the baited area. Twig growth was good in both the baited and unbaited areas in spite of the fact that the trees were damaged by the winter freezes of 1929–1930. It will also be noted that the 1,001 record traps in the peach trees caught few moths during the season.

Other than some of the common flies and small noctuids, very few insects were caught in the traps. The screen, of course, excluded all the larger insects but did not interfere with the capture of oriental fruit moths.

Only 23 codling moths were caught in the peach trees and one in the apple trees. Fifty oriental fruit moths were caught in the apple trees.

The traps had no noticeable effect on parasitism. It was impossible to determine the actual percentage of parasitism of oriental fruit moth

larvae because of the various prunings which were made before the twigs could be collected.

TESTS WITH OTHER POSSIBLE BAITS: The experimental block consisted of a solid block of 566 trees within the baited area. One trap was used in each tree. There were 70 different materials used in 13 combinations.

TABLE 2. ORIENTAL FRUIT MOTHS CAUGHT IN THE TEN BEST SOLUTIONS OF BAITS DURING THE SUMMER OF 1930, VINCENNES, INDIANA

Description of Solution Each trap with a wire screen[1] over the mouth contained 1 quart of water plus 3 ounces of granulated sugar with one of the following with exceptions as noted Below:	Duration of Test	Jars *Number*	Moths Caught *Number*	Average per Trap *Number*
Methyl cinnamate[2]	July 9–Sept. 20	3	333	111.00
Imitation concentrated maple flavor[3] plus B. P. J., 1–3[4]	June 9–Sept. 20	1	107	107.00
Bromo styrol[2]	July 9–Sept. 20	3	278	92.66
Anethol[2]	July 9–Sept. 20	3	270	90.00
Imitation concentrated nectarine flavor[3] plus B. P. J., 1–3	June 6–Sept. 20	1	89	89.00
B. P. J., 1–3	June 25–Sept. 20	15	923	61.53
Anethol	June 9–Sept. 20	3	184	61.33
Diethyl phthalate	June 10–Sept. 20	3	154	51.33
Ethyl caproate	June 10–Sept. 20	3	128	42.66
Benzyl cinnamate	June 25–Sept. 20	3	111	37.00

[1]Screen of ¼ inch mesh.
[2]Brown sugar instead of granulated sugar.
[3]Used ¾ ounce first filling, 10 cc. all remaining fillings.
[4]B. P. J., 1–3 = Boiled peach juice, 1 part to 3 parts water by volume. This peach juice was made by boiling 20 pounds of fresh peaches in 5 gallons of water for one hour. The liquid was then drained off and placed in a wooden barrel. The peach pulp was squeezed in a tight sack and the thick fluid acquired was then added to the liquid first obtained.

It was evident during the entire season that the experimental baits were more attractive than the molasses-citral bait. This seems to suggest that a variety of baits might be more attractive in a given area than one bait. It is possible that the baits in the small-scale experimental block drew the moths in from the surrounding territory.

During the season the 1,200 record molasses-citral traps caught a total of 1,290 oriental fruit moths while the 566 experimental traps caught a total of 8,609.

In Table 2 it will be seen that methyl cinnamate with brown sugar was the best solution used in the experimental block.

The results in Tables 1 and 2 are difficult to analyze. While the data indicate that the traps appear to have no beneficial effect, the following factors must not be overlooked.

1. The spring brood of moths emerged before the traps were placed in the orchards.

2. The experimental tests with other solutions indicate that the molasses-citral solution was much less attractive than some of the others, owing apparently to the use of an inferior grade of blackstrap molasses.

3. Trees in the baited area carried a heavier overwintering population.

4. There was no peach crop.

5. The high summer temperatures, low humidity, and drought very likely caused a high mortality of oriental fruit moth larvae and eggs. Premature hardening of the wood reduced the normal quality and quantity of food for the larvae and many died in the twigs.

Investigations at Cornelia, Georgia

Personnel: Permanent staff, three; temporary, six field assistants devoting practically all their time to collection of data; a foreman, three teamsters, and twelve to fifteen laborers, two of the latter assisting with twig collections, the others changing solutions in the large bait area.

The 500-acre Experiment: All the peach trees and most of the apple trees within a rectangular area 2 miles long and about 1 mile wide were baited, one trap per tree. Since the trees in this locality are smaller and more closely planted than at Vincennes it was necessary to bait 47,122 peach trees and 3,830 apple trees, or a total of 50,952 trees in order to cover 500 acres. The baited area was divided into 18 peach and 4 apple orchards. Twenty-three peach and two apple orchards at distances ranging from one-fourth mile to 4 miles from the baited area were selected as checks. These represented approximately 600 acres or 60,000 trees. Most of them were located northeast and southwest of the baited block, which extended northwest and southeast. Prevailing winds are from the northwest.

The same type of trap as used at Vincennes was employed but the bait consisted of 75 pounds of granulated sugar and six gallons of juice from condemned canned peaches in 100 gallons of finished solution. On June 28 a cheap grade of refinery seconds brown sugar was substituted for the granulated sugar and from August 1 to 18 juice boiled out of fresh peaches was used at the rate of 12 gallons in 100 gallons of solution.

Methods of handling were much the same as those employed at Vincennes. Instead of pouring the contents of the traps on the ground at each refilling, they were strained through burlap sacks attached to each side of the refilling tanks. The liquid was allowed to drain to

the ground but all insects were retained. Traps were filled at the tanks through faucets or a short hose. Eight fillings were made during the season, the first after spring-brood emergence had ceased.

All oriental fruit moths and codling moths captured by 2,000 traps divided among the orchards at the ratio of 1 to every 25½ trees were removed about four times weekly and recorded. In the baited area 920 trees were marked and all injured twigs removed at intervals during the season. In the check area 980 trees were used for this purpose. Twig growth was measured on half of the twig-injury record trees in July and again in September. At harvest all the fruit from 571 peach trees in the baited area and from 545 in the check area was cut for the determination of worm injury. Fruit cut totaled 135,826 peaches or almost 700 bushels. In addition from September 1 to October 30, 98,000 apples were examined for oriental fruit moth injury.

All newly injured twigs taken from each orchard at each twig collection were held separately and the larvae and parasites reared to maturity. Parasitism by native larval parasites, however, amounted to less than 1 per cent.

RESULTS: Although Tables 4, 5 and 6 indicate that the bait traps effected a reduction in twig and fruit infestation of approximately 50 per cent, the importance of these data are minimized owing to the extremely light infestation. In addition the overwintering brood appears to have been 45 per cent less in the baited area. This figure is based on the average number of twigs injured per tree by first-brood larvae in each area. The bait traps were not in operation until after spring-brood emergence had almost ceased. After maturation of the first brood the average increase in twig injury in the baited orchards was 6.5 times while the unbaited orchards averaged an increase of 7.9 times. It would appear that the relative abundance of the insect in the two areas was maintained throughout the season. As at Vincennes, seasonal conditions were abnormal, the spring-brood was missed and the solution used, unfortunately, had never been tested in this area or under such seasonal conditions. It proved only 25 per cent as attractive as certain other solutions developed in experimental tests with other baits (Table 7). More than 40 of 414 bait solutions tested were superior in attractiveness to the peach juice-sugar combinations. The substitution of refinery seconds brown sugar for granulated sugar in the formula late in June was a mistake. Experimental tests later indicated that the combination was less attractive than the granulated sugar-peach juice combination and even less attractive than refinery seconds sugar without peach juice.

The 2,000 record traps captured 3,859 oriental fruit moths and 1,868 codling moths. Of these, 135 oriental fruit moths and 1,538 codling moths were captured in apples where 147 of the 2,000 traps were located. The estimated catch for the 50,952 traps, based on the catch made by record traps in each orchard, totaled 96,950 oriental fruit moths and 48,800 codling moths. The largest apple orchard baited covered 40 acres. Oriental fruit moths were taken in all parts of it after peach harvest. The total number estimated as having been captured in apples was 3,830.

Of the 3,859 oriental fruit moths taken from record traps in peach trees, 6.4 per cent were captured from May 26 to May 31, 25.5 per cent during June, 39.5 per cent in July, 23.1 per cent in August and 5.5 per cent in September. Of the 135 oriental fruit moths captured in apple trees, 1.5 per cent were taken before June 1, 8.9 per cent in June, 23 per cent in July, 54 per cent in August, and 12.6 per cent in September. In peach trees, therefore, 71.4 per cent of the season's catch occurred before August 1, whereas in apple trees 33.4 per cent was made before that date. The decline in moth abundance after July emergence is well illustrated by these figures. The early and continued migration into apple trees was probably somewhat increased by the presence of traps therein. Among 6,968 worms found in apples between September 1 and October 30, only 1.2 per cent were oriental fruit moth larvae. Codling moth injury averaged nearly one entrance per apple.

The actual capture of moths by traps was observed at dusk and at no time did the screen appear to hinder entrance into the trap.

Releases of *Macrocentrus ancylivora* Roh. were made one-half mile from the baited area by the Georgia State Board of Entomology. This parasite was reared from twig collections in three of the baited and six of the unbaited orchards. One mile of baited territory was between two of these orchards and the point of release. No evidence could be found which might indicate that the bait traps would affect the establishment of this parasite.

Lack of space prevents a discussion of some interesting correlations relative to factors affecting intensity of infestation which are shown in Tables 4 and 5.

Tests with Other Possible Baits: Beginning in June some 800 traps, later increased to 988, were used to test the attractiveness of 414 different chemical-ferment combinations, fermenting sugars, and fruit juices. Fifteen flavors and 85 essential oils were each tested in combination with 10 per cent stock solutions of corn syrup, medium brown sugar, blackstrap molasses, and granulated sugar. In all these

tests at least two widely separated traps for each bait combination was used. Solutions used in the large-scale bait area were also tested along with many other fermenting baits. From 10 to 60 traps of each were used.

TABLE 3. SHOWING CAPTURES OF MARKED RELEASED ORIENTAL FRUIT MOTHS, CORNELIA, GEORGIA, 1930

Date Released	Moths Released *Number*	Date Recovered	Moths Recovered *Number*	Moths Recovered *Per cent*	Females Recovered *Number*	Average Egg Content Mature *Number*	Average Egg Content Immature *Number*
July 8....	55	July 9	21	38.2	Sex not determined		
		July 10	12	21.8	7	0	93
		July 11	5	9.1	3	6.3	54.6
		July 12	5	9.1	1	27.0	81.0
Total...	55		43	78.2			

Distance traveled—
July 9, one traveled 100 yards in the windward direction.
July 10, three traveled over 100 yards in different directions; one at least 200 yards to extreme end of baited area.
July 11, three traveled 200 yards to opposite corners of the 14-acre block.
July 12, taken from all parts of the area.

This special baited area covered 14 acres. Every second row of trees was baited. During the season these traps captured over 10,000 moths, or an average of 11 per trap, while the large 500-acre area, which lies one-fourth mile to the southwest, averaged two per trap. It is believed that the larger catch per trap was due to the use of only half as many traps per acre, to the small size of the area, to the presence of more attractive solutions, and possibly to a mixture of odors. Undoubtedly check orchards 21 and 23, one-fourth mile east and southeast, were affected by this experimental block. Some of the more attractive solutions and the results obtained by their use are given in Table 7.

EGG CONTENT OF ORIENTAL FRUIT MOTHS: Female moths reared in the laboratory did not contain mature eggs until the second or usually the third day after emergence. The average egg content of 56 laboratory-reared moths of this age was 2.6 mature and 102.7 immature eggs. No eggs had previously been deposited by them. Only the developing eggs retained in the ovarian tubes were classed as immature.

The average egg content of 132 trapped females was 18 mature and 65.7 immature eggs, indicating that some but not much oviposition had occurred before capture, also that moths are not readily attracted to traps until the second or third day, at which time they are ready to begin oviposition. The greatest number of eggs found in one female oriental

TABLE 4. SUMMARY OF INFESTATION RECORDS AND RELATED DATA FOR INDIVIDUAL PEACH ORCHARDS IN THE AREA BAITED FOR THE ORIENTAL FRUIT MOTH AT CORNELIA, GEORGIA, IN 1930

Orchard No.	Trees and Traps *Number*	O. F. M. Caught per Tree, May 26 to Oct. 1 *Average Number*	Twigs injured per Tree Entire Season[1] *Average Number*	Average Twig Growth to Mid-July[2] *Cm.*	Variety	Average Age of Trees *Years*	Fruits per Tree at Harvest *Average Number*	Fruit injured by O. F. M. at Harvest[3] *Per cent*	O. F. M. Entrances in Fruit per Tree[3] *Average Number*
1	2,928	2.26	20.9	14.3	Elberta	12	149	4.82	7.27
2	2,544	1.41	22.6	12.0	Elberta	12	139	1.73	2.44
3	999	1.49	14.0	9.1	Elberta	19	135	2.47	3.33
4	760	1.19	10.7	12.2	Elberta	19	55	8.07	4.50
5[4]	2,870	1.86	18.7	15.6	Elberta	12	128	1.11	1.42
					Ga. Belle	10	554	.36	2.00
6[4]	2,328	1.28	7.4	10.1	Elberta	9	211	3.87	8.27
					Ga. Belle	19	292	1.71	5.18
7	2,407	.76	25.0	24.7	Elberta	4	42	3.32	1.43
8	3,840	1.34	19.3	12.0	Elberta	7	188	2.25	4.29
9	4,944	2.47	20.4	11.4	Elberta	10	318	1.48	4.76
10	966	2.56	17.5	10.4	Ga. Belle	7	153	4.90	7.50
11	3,829	4.41	37.4	19.3	Elberta	5	93	3.42	3.22
12	904	2.73	41.0	24.7	Elberta	3	0	—	—
13	3,889	1.60	19.1	14.6	Elberta	14	42	7.10	3.60
14	2,312	1.50	10.5	12.7	Elberta	14	96	3.61	3.20
15	3,182	1.78	13.6	12.5	Elberta	10	74	3.36	2.48
16	1,400	1.77	20.2	12.4	Elberta	8	134	1.59	2.13
17	5,628	1.61	14.7	12.3	Elberta	14	64	4.75	3.20
18	1,392	3.30	5.7	10.1	Elberta	7	190	2.17	6.33
Average all orchards		1.96	18.8	13.9		10.7	161	3.27	4.03

NOTE: Varieties—Elberta (95 per cent) and Georgia Belle (5 per cent).
Harvest—From July 31 to August 11, inclusive.
[1]Based on records for 920 trees.
[2]Twenty-five uninjured uniformly distributed terminal twigs were measured on half the twig record trees.
[3]Based on records for the entire crop from 571 trees. All fruit examined internally.
[4]Both varieties represented in first four columns.

TABLE 5. SUMMARY OF INFESTATION RECORDS FOR THE ORIENTAL FRUIT MOTH AND RELATED DATA FOR INDIVIDUAL PEACH ORCHARDS IN THE UNBAITED AREA AT CORNELIA, GEORGIA, IN 1930

Orchard No.	Estimated Number of Trees	Twigs Injured per Tree Entire Season[1]	Average Twig Growth to Mid-July[2]	Variety	Average Age of Trees	Fruits per Tree at Harvest	Fruit Injured by O. F. M. at Harvest[3]	O. F. M. Entrances in Fruit per Tree[3]
		Number	*Cm.*		*Years*	*Average Number*	*Per cent*	*Average Number*
19	1,000	62.4	32.3	Elberta	4	56	5.82	3.31
20	3,500	69.9	15.9	Elberta	7	227	7.76	18.31
21	2,500	46.7	13.7	Elberta	20	82	4.96	4.17
22	2,000	22.5	6.8	Elberta	20	100	8.38	8.56
23	1,800	9.4	7.2	Elberta	8	54	5.23	3.00
24	3,500	31.8	9.2	Elberta	16	48	18.11	9.00
25	1,800	20.2	14.3	Elberta	6	20	15.96	3.36
26	2,600	16.7	11.5	Elberta	9	34	21.05	7.48
27	400	21.8	11.3	Elberta	9	0	—	—
28	2,500	29.8	7.3	Elberta	16	136	9.25	12.83
29	2,000	43.2	11.4	Elberta	17	154	5.24	8.08
30[4]	5,000	17.6	15.3	Elberta	8	217	5.24	11.52
				Ga. Belle	5	383	6.13	24.63
31	3,000	27.3	18.6	Elberta	8	172	1.55	2.70
32	800	75.6	28.5	Elberta	3	22	6.01	1.33
33	1,000	70.9	30.1	Elberta	3	29	5.35	1.57
34[4]	4,000	10.7	6.2	Elberta	20	86	1.40	1.20
				Ga. Belle	10	67	3.45	3.00
35	2,000	7.3	9.1	Elberta	8	74	2.48	1.87
36	1,000	74.1	30.9	Elberta	3	35	3.14	1.09
37	3,000	73.9	29.2	Elberta	3	51	4.03	2.17
38	4,000	32.1	19.4	Elberta	8	212	2.53	5.49
39	2,000	45.6	11.8	Elberta	9	[5]	[5]	[5]
40	3,200	35.3	16.2	Elberta	10	100	5.59	5.73
41	6,000	14.3	17.6	Ga. Belle	12	105	3.13	3.35
				Elberta	8	130	2.62	3.55
Average all orchards		37.3	16.2		9.6	103	6.43	6.13

[1]Based on records from 980 trees.
[2]Twenty-five uninjured uniformly distributed terminal twigs were measured on half the twig record trees.
[3]Based on records for the entire crop from 545 trees. All fruit examined internally.
[4]Both varieties represented in first three columns.
[5]No fruit examined.

fruit moth was 192, all of them immature. The greatest number of mature eggs found was 48. This female also contained 109 immature eggs.

PERCENTAGE OF MOTHS CAPTURED BY TRAPS: At the peak of second-brood emergence in July, 55 oriental fruit moths marked with alcohol-soluble eosin and less than 12 hours old were released in the center of the 14-acre experimental block. See Table 3 for moth recovery.

TABLE 6. A COMPARISON OF AVERAGE TWIG GROWTH, TWIG AND FRUIT INFESTATION BY THE ORIENTAL FRUIT MOTH AND WORM POPULATION, IN BAITED AND UNBAITED PEACH ORCHARDS AT CORNELIA, GEORGIA, IN 1930

Location	Twigs Injured per Tree[1]	Average Twig Growth to Mid-July[2]	Fruits per Tree	Fruit Injured[3]	O. F. M. Entrances in Fruit per Tree[3]
	Number	*Cm.*	*Number*	*Per cent*	*Number*
Average by Orchards in:					
Baited area (18 orchards, 47,122 trees)	18.8	13.9	161	3.27	4.03
Entire unbaited area (23 orchards, 58,600 trees)	37.3	16.2	103	6.43	6.13
Unbaited area excluding orchards within ⅜ mile of traps (15 orchards, 44,500 trees)	35.8	15.0	125	7.16	7.55

NOTE: Orchards within ⅜ mile are Nos. 19, 21, 22, 23, 31, 32, 33, and 35. See Table 5.

[1]Based on records for 1,900 trees.

[2]Twenty-five uninjured uniformly distributed terminal twigs were measured on half the twig record trees.

[3]Based on records for the entire crop from 1,116 trees. All fruit examined internally.

Again on August 27, 13 marked moths were released near the same point. Seven were recaptured during the first two nights, five of those recovered being females. Two had traveled more than 150 yards. The farthest corner of the baited block was reached before the fifth day, by which time two more moths had been recovered, making a total recovery of 69.2 per cent. The average number of eggs in the females recovered was 10 mature and 98 immature.

On August 17, after peach harvest, 40 marked moths were released in unbaited orchard No. 23, one-fourth mile northeast of the 14-acre experimental block's nearest corner. Peach and apple trees surrounded the point of release and covered the area between it and the baited block. Two captures were made near the center of the baited block on the fourth night. Distances traveled were 530 and 560 yards. One of the moths was a female containing 89 immature eggs. A male was captured on the eighth night 520 yards from the point of release. On the

TABLE 7. ORIENTAL FRUIT MOTHS CAUGHT IN SOME OF THE MORE ATTRACTIVE BAIT SOLUTIONS TESTED AT CORNELIA, GEORGIA, IN 1930

Stock Solution of 10 per cent	Duration of Tests and Moths Caught per Trap: June 16–Sept. 10 Brown Sugar Med. Grade	June 16–Sept. 10 Gran. Sugar	June 16 to July 23 Blackstrap Molasses	July 23–September 10 Brown Sugar Med. Grade[1]	July 23–September 10 Brown Sugar Med. Grade[2]	July 23–September 10 Corn Syrup[3]
Plain stock solution: 10 traps of each	26.5	3.7	2.3	5.7	11.1	9.6
Aromatics used 10 drops per quart of stock solution. 2 traps of each used except where 6 traps were used						
Ethyl cinnamate	69.5	20.0	2.5	24.0	31.6	18.5
Terpinyl acetate	52.0	18.0	1.0	16.5	28.1	12.0
Bromo styrol	41.0	8.0	1.0	8.0	18.5	8.0
Oil mace	37.5	7.5	2.0	8.0	23.1	10.5
Thujone	37.5	4.5	1.0	12.5	12.5	5.0
Geranyl acetate	37.0	8.0	0.0	16.0	17.6	6.0
Oil eucalyptus	36.0	7.0	1.5	10.5	—	8.5
Methyl acetate	35.5	3.0	0.5	10.5	15.8	3.5
Dimethyl acetophenone	35.0	3.5	3.5	10.5	16.6	8.5
Flavors used 6 cc. per quart of stock solution: 2 traps of each were used.						
Pistachio	45.0	0.5	0.0	16.0	—	6.5
Pear	44.5	3.5	0.5	10.5	—	7.5
Nectarine	40.5	4.0	0.0	11.5	—	9.5
Ferments						
Six per cent fresh boiled peach juice: 20 traps used	—	18.3	—	—	—	—
Six per cent canned peach juice[4]: 60 traps used	—	12.3	—	—	—	—

[1]This set of traps is the same as that listed in column 1.
[2]Six traps were used with each of these baits.
[3]Commercial brand, consisting of a mixture of corn syrup and refiners syrup.
[4]This solution was used in the 500 acre experiment until June 28.

ninth night a female was captured at the farthest corner of the baited area, a distance of 760 yards. She contained 8 mature and 44 immature eggs. The average distance traveled by the captured moths was one-third mile. Recovery from the release made one-third mile or more away was 10 per cent. Wind blew lightly toward the baited area on the fifth night. On the other evenings it blew at right angles to the line of flight to the traps except the night of release when it came out of the area.

Further investigations along this line are essential. If 10 per cent of the moths emerging one-third mile away can be captured in a block as small as this along with 70 per cent of those emerging inside, then the numbers coming from outside might be several times as great as the number naturally present.

This may explain why small-scale tests have never given satisfactory control especially where near-by orchards were used as controls. It may also explain why the traps in this small area captured five times as many moths each as those in the 500-acre block. If a small block of this size has so much drawing power what might not the large area have?

The tendency of oriental fruit moths to disperse following emergence, as indicated by recoveries within the experimental block, may have tended to equalize the natural infestation within and outside the large bait area.

HIBERNATION OF *PECTINOPHORA GOSSYPIELLA* IN TEXAS

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ABSTRACT

The results of three years' studies on the hibernation of the pink bollworm are presented. It was found that in the cotton field the greatest number of the overwintering stages were in bolls on the stalks, although a considerable number were in shed forms or cocoons in trash on the surface of the ground. A comparatively small percentage were in the soil. Averages for three years show that the final survival in bolls buried 4 inches but not irrigated was greater than in bolls on the surface of the soil when not irrigated, though this ratio was reversed in sandy-loam soil or when bolls were buried in the month of March. An irrigation of surface bolls increased the survival. March burial of 4 inches produced greater mortality than December burial at the same depth, without irrigation in either case. Immediate irrigation of bolls buried 4 inches caused much greater mortality under certain conditions than occurred in bolls buried the same depth but not irrigated, but three-year averages under such irrigation in all soil types studied and for all months show very little difference. Delaying irrigation three months after burial greatly increased

survival over that in bolls buried 4 inches but not irrigated or in bolls buried 4 inches and irrigated at once. The survival in bolls in sandy loam was much lower than in bolls in silty-clay soil.

Experiments were conducted for the purpose of determining the overwintering survival of the pink bollworm at Castolon and Presidio, Tex. The data presented were averaged from the results of nearly three years' experiments from November, 1927, when the work was started at Castolon, to August, 1930, when it was brought to a close at Presidio. There was one season's work at Castolon, followed by two at Presidio.

The survival was determined under the following conditions: (a) in bolls attached to cotton stalks; (b) in bolls resting on the surface of the soil; and (c) in bolls buried at various depths in the soil. The experiments at Castolon were carried out in one soil type, a mixed sandy adobe with the adobe predominating. At Presidio the tests were conducted in two soil types, a light sandy soil and a heavy silty-clay or adobe soil. All bolls in the soil or on the surface were placed in cages or in screen cylinders in small plots, where they could be irrigated at will. These plots were surrounded by borders sufficiently high so that at least 7 inches of water could be applied. For all plots where an irrigation was given or where the bolls were buried, there were check plots which were never irrigated or where the bolls were left on the surface. In this paper, therefore, by "plot" is meant a small section of the experimental field completely surrounded by borders of soil thrown up so that it could be either irrigated or protected from the irrigation of adjacent plots. The emergence cages and screen cylinders were located within these plots.

Methods

Selection and Preparation of Plots.—The plots where the hibernation work was to be conducted were selected first on the basis of soil type. Other considerations were ease of irrigation, absence of any cotton which could harbor pink-bollworm infestation, and protection from flood waters. The soil was then carefully leveled, irrigation ditches were constructed, and borders of soil were thrown up around each plot according to a prepared diagram which showed the exact number and arrangement of all the plots.

Collection of Infested Material.—Heavily infested cotton bolls which had partially opened and dried out were selected for the experimental work. All green or frosted bolls were carefully excluded. Those selected for the tests were picked in heavily infested fields, sacked, labeled, and stored at the laboratory for later use. Whenever possible,

1

2

3

1, Standard moth emergence cage with moth trap installed. 2. Screen hibernation cylinder as installed with layer of cotton bolls on surface of soil. 3. Screen hibernation cylinder with wire cut and soil removed to show layer of buried cotton bolls.

all material was picked from the same field and on the same date, but owing to the extensive nature of the experiments this was not always possible. The bolls were gathered in November before frost.

DETERMINATION OF INFESTATION.—Just before the date when the bolls were to be placed in the screen cylinders or cages, a sample of at least 100 was selected and each boll and the seeds within were carefully cut by hand to determine the number of live mature, live immature, and dead larvae. Usually 20 bolls per sack were examined, so the sample often represented several hundred. By determining the average number of live mature larvae per boll in the sample and multiplying this figure by the total number of bolls used in each test, the total number installed per cage, cylinder, or treatment could be calculated.

THE EMERGENCE CAGE.—The standard emergence cage was a frame of wood 1 square yard in inside dimensions, made of four 8 by ¾ inch boards firmly nailed together, braced, and primed to prevent warping. A 6-inch board with a hole 2½ inches in diameter cut in the center was nailed across the center of the top. The moth trap was later placed over this hole.

Each cage was set in the soil within the plot so that the surface of the soil within the frame was flush with that outside and there were 4 inches between the top of the cage and the soil beneath. Into each frame were placed 250 infested bolls. The top was then covered with 16-mesh galvanized screen wire in order to prevent surface bolls from floating away during an irrigation and to protect them from birds, etc. Whenever the treatment called for later burial of the bolls in such cages, the screen wire was removed, the layer of bolls carefully sacked, the soil within the cage dug to the proper depth, the bolls replaced and covered with the same soil, and the screen wire replaced on the top.

Early in April the screen wire was removed and the top of each cage covered with heavy black sateen except over the hole where the moth trap was to go. The trap was then set in place (Plate 49, 1). It was of the familiar domed flytrap model without the bottom pan, but was made of 18-mesh galvanized screen wire. The inner part, or cone, was securely nailed over the hole, and the outer part, or cap, fitted tightly over the cone but could easily be removed by hand. The traps were examined every morning during the period of moth emergence, since any moths emerging and entering them during the preceding night were unable to reenter the cages during the day.

THE SCREEN CYLINDER.—The screen cylinder (Plate 49, 2 and 3) was a device used for inclosing bolls that were either placed on the surface of the soil or buried in it for later examination to determine the per-

centage of mortality. It was made of 16-mesh galvanized screen wire and reinforced with three stakes. It was 18 inches high and of sufficient diameter so that it could contain 75 cotton bolls without overcrowding. In each plot there was both an emergence cage and a screen cylinder containing bolls with similar percentages of infestation and treated in the same way. The number for each treatment was determined on the basis of the expected number of later boll examinations for the estimation of mortality. Each cylinder was set in its respective plot so that it extended 6 inches below the surface of the soil and 12 inches above.

When the bolls in the cylinder, either buried or on the surface, were to be examined, they were separated from the soil, placed in paper bags, labeled, and brought into the laboratory for cutting. The soil was removed to a depth of 6 inches and brought to the washing cradle for further treatment.

THE WASHING CRADLE.—The washing cradle was a box 3 feet long, 2 feet wide, and 2 feet high, made of 18-mesh galvanized screen wire tacked to wooden supports, reinforced with ¼-inch-mesh hardware cloth, and open at the top. It was provided with handles so that it could be operated by two men. The cradle was set upon a submerged wooden support in the river so that the current passed through it but not over the top. The force of the water, together with a gentle rocking movement from the operators, forced all the fine silt into the river, leaving in the cradle only the trash, bits of broken bolls, cottonseeds, and all larvae and cocoons that were loose in the soil. This material was then removed and placed in screen trays for drying and later examination.

DETERMINATION OF SURVIVAL IN BOLLS ON PLANTS.—To determine survival in bolls attached to cotton plants, the bolls were tied to dried stalks set upright in the hibernation plots, and later picked and examined in the same way as described for the other treatments in estimating mortality percentages. Emergence was determined by covering the plants with screened field cages 4 feet square. Early in April these cages were covered with black cloth and provided with several moth traps.

FIELD SAMPLING.—The field distribution of the pink bollworm during the winter months was determined as follows: Two points in each field were selected as nearly as possible representative of the predominating soil types. At each point 1 square yard of surface trash and soil to a depth of 6 inches was examined for presence of cocoons with larvae and pupae according to the methods just described. Three plants per point were also selected as representing the number per square yard, and all

squares and bolls on these plants were picked and examined. Since very few roots harbored overwintering cocoons, a considerable number were pulled and examined. The results from these sources were then tabulated and computations made to determine the number and percentage of live and dead overwintering larvae per square yard in squares and bolls on the plants; in shattered plant forms or in trash on the surface of the soil; in cocoons on the plant roots; and in cocoons, seeds, etc., loose in the soil. This gave information not only as to the location of the pink bollworm in the cotton fields and the proportion overwintering for each particular type of habitat, but also concerning the number per square yard, which in turn could be computed on an acre basis.

IRRIGATION.—Water for irrigation was pumped from the river or from a well. The amount used in each plot scheduled for irrigation was exactly 7 inches as measured by a rectangular weir and water stage recorder.

RECORDS.—All emergence records were kept daily on specially prepared forms and the sex of the moths was determined whenever possible. Records for mortality determinations in the boll examinations were kept in field notebooks. In the mortality records the number of live larvae, pupae, or moths found in bolls, loose seeds, trash from washings, or in the soil at date of examination were kept separate as to the type of material examined. This information was later compiled according to the plot and treatment. Air temperature and humidity data were taken from an hygrothermograph located at the plots in the adobe soil. In 1930 continuous surface-soil temperatures were taken in the adobe soil. Except where otherwise stated, the conclusions in this paper as to percentage of survival under different conditions are based on emergence records.

PRESENTATION OF DATA

PLACE OF HIBERNATION OF THE PINK BOLLWORM IN THE FIELD.—It was found that in early winter a majority of the long-cycle larvae were in bolls and squares on the plants, with a considerable proportion in hibernacula on the surface of the soil and a few actually in the soil. To determine this field distribution of the pink bollworm, a careful field and soil examination was made in one field at Castolon, December, 1927, and in four fields in Presidio County, January, 1929. Two samples were taken from the field at Castolon and eight, or two each, from the four fields in Presidio County. These data have been summarized and averaged as shown in Table 1. The two-year average shows that 68.59 per cent of all the larvae were in bolls and squares on the plants, 29.23 per

cent in shed squares and bolls or cocoons on the surface of the ground, and 2.18 per cent in cocoons on the roots or loose in the soil. The mortality on the plants was 29.57 per cent, in the surface trash 22.45 per cent, and in the soil nil. The figure for mortality in the soil is not reliable because the stages disintegrate in the soil shortly after death.

TABLE 1. FIELD DISTRIBUTION AND MORTALITY OF LONG-CYCLE LARVAE OF *Pectinophora gossypiella* AT PRESIDIO AND CASTOLON, TEX., 1927 AND 1929

Distribution	Quantity Examined	Dead Larvae	Live Larvae	Per cent All Stages Found per Square Yard	Per cent Mortality
On plants	30 plants	34	81	68.59	29.57
In surface trash	10 sq. yds.	11	38	29.23	22.45
On plant roots and soil	124 plants and 10 sq. yds. of soil	0	3.66*	2.18	0
Total		45	122.66		

*Based on three plants per square yard.

SURVIVAL IN BOLLS ON PLANTS.—The survival of the pink bollworm in bolls attached to plants was studied during the winters of 1927–28, 1928–29, and 1929–30 by means of periodic examinations of bolls for mortality percentages. During the first two winters the plants and bolls were within large, screened field cages; during the last winter they were left in the open. In 1927–28 there were enough bolls on the plants in the cages so that large samples could be picked for examination each month from March to December, inclusive. Thus it was possible to study summer dormancy as well as winter mortality.

The survival in bolls attached to plants was very high in 1927–28. A mortality of only 34.98 per cent was found in the sample examined on March 9, and in a smaller sample examined on April 26 it was only 23.64 per cent; in the sample examined on May 23, however, the mortality was found to be 61.08 per cent, and each sample subsequently examined showed an increased mortality. To explain the continued summer mortality during dormancy, it may be stated that the larvae in dried bolls on plants were not exposed to the action of soil moisture due to rains and irrigations, and therefore a much smaller percentage of them pupated and emerged as moths. These examinations revealed the fact that live dormant larvae were in these bolls on the plants as late as October 16.

Determinations made in March of both the following years showed that the mortality was much higher than in 1927–28. Therefore, the three-year average was considerably increased. The examinations were not carried beyond June 19, 1929. No live stages were found in the one

examination made on March 10, 1930. In 1930 two heavy freezes killed most of the long-cycle larvae in exposed positions, such as in bolls hanging on the plants. The possible protective effect of the cage was also absent this year. The three-year average shows a mortality late in March, and therefore not final, of 63.97 per cent of all stages (Table 2).

TABLE 2. MORTALITY IN LATE MARCH OF *Pectinophora gossypiella* IN BOLLS HANGING ON PLANTS, PRESIDIO AND CASTOLON, TEX., 1927–30

Locality	Year	Average Number of Live Larvae Installed per Boll	Date of Installing Bolls in Cages	Number of Bolls Examined in March	Number of Live Larvae Recovered	Estimated Per cent Mortality*
Castolon	1927–28	4.06	Dec. 6	75	198	34.98
Presidio	1928–29	3.25	Dec. 10	50	70	56.92
Presidio	1929–30	2.22	Dec. 10†	75	0	100.00
Average						63.97

*Based on number of live mature larvae for equal number of bolls when experiment was started.
†Bolls tied on plants in open.

SURVIVAL IN BOLLS ON SURFACE OF SOIL.—Over the three-year period, according to boll examinations, the mortality in bolls on the surface of the soil was somewhat lower than in those on the plants. Three-year averages show a mortality in late March of 61.46 per cent in surface bolls irrigated either in December or in March and 58.68 per cent in nonirrigated surface bolls. These figures do not give the final mortality, but are presented for comparison of survival in bolls on plants.

Moth-emergence records show a survival of 3.94 per cent in surface bolls irrigated in early December, 6.57 per cent in surface bolls irrigated in early March, or an average of 5.26 per cent for surface bolls irrigated on both dates. On the other hand, the survival in dry surface bolls was 2.51 per cent (Table 3). In sandy loam the survival in surface bolls irrigated in December for the two-year period was greater than that in the surface bolls irrigated in March. The reverse was true in silty-clay soil. There was also considerable yearly variation from the average trend.

SURVIVAL OF STAGES IN SOIL

EFFECT OF 4-INCH BURIAL OF BOLLS WITHOUT IRRIGATION.—The average survival of the pink bollworm in bolls buried 4 inches in unirrigated plots for the three-year period under all soil conditions, as determined from moth emergence, was 3.20 per cent as compared with 2.51 per cent in nonirrigated surface bolls (Table 3). Thus, burial 4

TABLE 3. SUMMARY OF SURVIVAL AS DETERMINED BY MOTH EMERGENCE OF THE PINK BOLLWORM, PRESIDIO AND CASTOLON, TEX., 1928–30

Treatment	Per cent Survival in— All Soils				Sandy Loam			Silty Clay		
	1928	1929	1930	Average	1929	1930	Average	1929	1930	Average
Bolls buried 4 inches Dec. 6–10, irrigated 7 inches Dec. 7–10	0.31	2.88	0.46	1.22	0.14	0.05	0.10	5.62	0.86	3.24
Bolls buried 4 inches March 1–8, irrigated 7 inches March 1–8	11.68	2.48	0.58	4.91	0.94	0.00	0.47	4.01	1.15	2.58
Bolls buried 4 inches Dec. 6–10 or March 1–8 and irrigated at once	6.00	2.80	0.49	3.10	0.30	0.03	0.17	5.29	0.95	3.12
Bolls buried 4 inches Dec. 6–10, not irrigated	6.07	4.39	1.00	3.82	1.08	0.00	0.54	7.69	1.99	4.84
Bolls buried 4 inches March 1–8, not irrigated	2.96	4.08	0.10	2.38	0.67	0.00	0.34	7.49	0.19	3.84
Bolls buried 4 inches Dec. 6–10, or March 1–8, not irrigated	4.52	4.36	0.71	3.20	1.04	0.00	0.52	7.67	1.41	4.54
Surface bolls, irrigated 7 inches water Dec. 5, 7, or 10	4.36	6.95	0.50	3.94	5.48	0.00	2.74	8.42	0.99	4.71
Surface bolls, irrigated 7 inches water March 1–8	13.55	6.02	0.15	6.57	0.40	0.30	0.35	11.63	0.00	5.82
Surface bolls, irrigated 7 inches water Dec. 8–10 or March 1–8	8.96	6.49	0.33	5.26	2.94	0.14	1.54	10.03	0.52	5.28
Surface bolls, not irrigated	2.02	4.75	0.77	2.51	2.94	0.09	1.52	6.55	1.44	4.00
Bolls buried 4 inches Dec. 6–10, irrigated 7 inches water March 1–8	11.68	5.80	—	8.74*	1.98	—	—	9.62	—	—

*Two-year average.

inches, when not followed by irrigation, decreased mortality somewhat over that in the dry surface bolls. A further analysis of the data on the basis of soil type shows an average survival of 0.52 per cent in bolls buried in sandy loam and an average of 1.52 per cent in bolls on the surface. Burial in sandy loam without irrigation therefore increased mortality. In silty-clay soil the survival in dry buried bolls averaged 4.54 per cent and in dry surface bolls 4.00 per cent. In this soil type burial decreased the mortality somewhat.

TABLE 4. EFFECT OF SOIL TYPE ON SURVIVAL OF PINK BOLLWORM AS DETERMINED BY MOTH EMERGENCE FROM CAGES IN ALL COMPARABLY TREATED PLOTS, BOTH BURIED AND SURFACE BOLLS, PRESIDIO, TEX., 1928–30

Year	Number of Cages Under Test		Number of Worms Installed		Number of Moths Emerged		Per cent Mortality	
	Silty Clay	Sandy Loam	Silty Clay	Sandy Loam	Silty Clay	Sandy Loam	Silty Clay	Sandy Loam
1928–29	46	46	33,354	33,354	2,207	692	93.38	97.93
1929–30	38	38	20,810	20,810	258	4	98.76	99.98
Total	84	84	54,164	54,164	2,465	696		
Average							96.07	98.95

EFFECT OF DATE OF BURIAL WITHOUT IRRIGATION.—The three years' records in all soil types, based on emergence data, show that the survival in bolls buried in December averaged 3.82 per cent, in bolls buried in March 2.38 per cent, and in check 2.51 per cent (Table 3). Thus March burial caused a greater mortality than December burial and the check was intermediate between the two. These records are for 4-inch burial only.

EFFECT OF IRRIGATION AND BURIAL COMBINED.—The effect on survival of a 7-inch irrigation following burial of bolls 4 inches was determined on the basis (1) of date of irrigation following burial and (2) of soil type. The records show an average survival (moth emergence) of 1.22 per cent for bolls buried 4 inches early in December and irrigated at once, 4.91 per cent for bolls buried 4 inches early in March and irrigated immediately, and 8.74 per cent for bolls buried 4 inches in December and irrigated three months later (Table 3). Two years' records based on soil type show that in sandy soil a burial of 4 inches in December plus immediate irrigation also caused a greater mortality than similar treatment in March. On the other hand, in the silty-clay soil the March burial of 4 inches with immediate irrigation resulted in the greater mortality.

EFFECT OF TYPE OF SOIL.—The survival was greater in bolls in the adobe soil than in those in sandy soil during the winters of 1928–29 and 1929–30. A total of 54,164 live larvae were installed in each soil type.

Of this number, 2,465 moths emerged from the silty-clay soil as compared with 696 from the sandy soil (Table 4). The mortality averaged 96.07 per cent in the silty-clay and 98.95 per cent in the sandy soil. This mortality occurred under all combinations of treatments.

PROGRESSIVE SEASONAL MORTALITY.—Each year from 1928 to 1930, inclusive, four spring and early summer examinations were made of infested bolls under all combinations of treatments herein discussed to determine per cent of mortality. These examinations were made late in March, April, May, and June. In December, 1927, 8,667 larvae were installed; in December, 1928, 21,792 larvae were installed; and in the same month in 1929, 54,120 were installed. Each examination during the spring following installation took into account one-fourth of the larvae under test. In all 84,579 larvae were used in the tests.

TABLE 5. PROGRESSIVE SEASONAL MORTALITY OF *Pectinophora gossypiella*, PRESIDIO AND CASTOLON, TEX., 1927–30

Year	Number of Larvae Used for Each Examination	Per cent Mortality at Examination in:			
		March	April	May	June
1927–28	2,166	48.03	88.56	93.40	93.45
1928–29	5,448	67.33	87.28	94.40	95.12
1929–30	13,530	86.44	95.84	97.68	98.69
Average		67.27	90.56	95.16	95.75

The March examinations, usually made between March 20 and 31, showed that the mortality ranged from 48.03 per cent in 1928 to 86.44 per cent in 1930, averaging 67.27 per cent for the three years (Table 5). As there was practically no moth emergence at this date, these figures are correct. To obtain the following mortality percentages, the percentage of moth emergence was taken into consideration. Thus, the April, 1928, examination indicated a mortality of 91.37 per cent, but as 2.81 per cent of the live stages installed had already emerged as moths, the corrected mortality was 88.56 per cent. In 1930 the April examination showed 95.84 per cent mortality, and the three-year average was 90.56 per cent. For May the average was 95.16 per cent and for June, 95.75 per cent. Therefore, although there was considerable mortality at the time of the March examination, there was a tremendous further increase between late March and late April.

Based on emergence-cage records, the average percentage of survival for three years was highest in 1927–28 at Castolon, 6.72 per cent, and lowest at Presidio in 1929–30, 0.84 per cent. In 1928–29 the average percentage of survival was 4.35. The three-year average was 3.97 per cent.

Summary

At Castolon and Presidio, Tex., 68.59 per cent of the overwintering stages were found in plant forms hanging on the plants, 29.23 per cent in shed stages or cocoons in surface ground trash, and 2.18 per cent in cocoons on tap roots of the plants or in the soil.

According to examinations of material in March, the mortality at that time was greater in bolls attached to plants than in those on the surface of the soil, whether or not the surface bolls were irrigated. The mortality percentages were: for bolls on plants, 63.97; for surface bolls unirrigated, 58.68, and for surface bolls irrigated, 61.46.

According to emergence records (i. e., final survival) irrigation of surface bolls increased survival in all experiments, but the increase was the least in the sandy-soil plots. The average percentages were, for surface bolls irrigated, 5.26, and for surface bolls unirrigated, 2.51. The corresponding figures for sandy soil were 1.54 and 1.52; for adobe soil, 5.28 and 4.00.

A 4-inch burial of infested bolls, when not followed by an irrigation, increased the final survival over that occurring in unirrigated surface bolls, the average percentages for all soil types for three years being 3.20 for the buried bolls and 2.51 for those on the surface. In sandy soil similar treatment increased the mortality, the figures for two years being 0.52 for buried bolls and 1.52 for those on the surface. In adobe soil the corresponding figures were 4.54 per cent for buried bolls and 4.00 per cent for those on the surface.

In unirrigated soils March burial of 4 inches gave greater mortality than December burial to a similar depth, the average survival being 2.38 and 3.82 per cent, respectively.

For the 4-inch burial in all soils at all dates, an immediate 7-inch irrigation caused a greater mortality than when the irrigation was delayed three months. In this experiment the averages show no marked increase in mortality in the bolls buried and immediately irrigated over those buried and not irrigated. The irrigation immediately following December burial caused the greatest mortality.

The type of soil has an important effect on survival. About four times as many moths emerged from bolls in the various treatments in silty-clay soil as in sandy-loam soil, the figures being 2,465 as compared with 696.

By months, the cumulative larval mortality percentages in bolls under all treatments, except on plants, was as follows: March, 67.27; April, 90.56; May, 95.16; June, 95.75.

Based on emergence records, the average survival from 1927 to 1930 was 3.97 per cent.

THE WELL-MARKED FRUIT-WORM,[1] *STENOMA ALGIDELLA* WALK.

By S. W. Frost, *The Pennsylvania State College*

Abstract

Stenoma algidella Walk., is recorded for the first time as a minor pest of apple, feeding both on fruit and foliage. Brief notes are given on its life history and habits. Apparently there is only one complete brood: the insect hibernates as pupae.

Stenoma algidella Walker, heretofore, has never been recorded as a pest on apple. It occurs quite commonly throughout the eastern United States, and during recent years, has been found abundant in many orchards in Pennsylvania, at times causing conspicuous injury. It is a foliage and a fruit feeder, eating large holes in the flesh of apples. It is sporadic in its attacks and, at present, must be considered as a minor pest. Under favorable conditions it might become more serious. A few notes on its life history may guide future investigators and fruit growers in dealing with this insect.

Common Name.—Since this insect has not been recognized as a pest, it has never received a common name. The conspicuous black markings on the full-grown larva suggest the name "Well-marked fruit-worm." It is considered a fruit worm because the females lay their eggs singly on the foliage rather than in masses, as is the habit with the leafrollers; Archips, Eulia, etc.

History.—The insect was described by Walker in 1864 (5) as *Stenoma algidella* and has remained in the original genus. Ide, Brachiloma and Harpalyce are recognized today as synonyms of Stenoma. Walsingham 1889 (6) suggested that *algidella* Walk., might be a color form of *schlaegeri* Zell., but subsequent writers have considered it distinct. It runs close to *schlaegeri* Zell., the latter being slightly larger in size and darker in color than *algidella* Walk. A species *leucillana* (authors) has been thrown in synonymy with *Stenoma algidella* Walk.

Stenoma algidella Walk., has attracted little or no attention by economic entomologists and, in fact, comparatively little appears in systematic entomology concerning this species. The writer first found it in Pennsylvania in 1918 and mentioned it in a paper in 1919 (2). In 1921 (3) it was noted as one of the green fruit-worms occasionally attacking apples. Since then nothing has appeared in economic literature concerning its habits or destructiveness.

[1]Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station as Technical Paper No. 518.

ABUNDANCE AND DISTRIBUTION.—Little is known about the distribution of *Stenoma algidella*. It was recorded from Nova Scotia by Walsingham (6) and apparently has a general distribution over the eastern United States. It has been reported from a number of localities in New York State, and the writer has taken it in eleven counties in Pennsylvania where it is, no doubt, abundant and widely distributed. Both larvae and adults are conspicuously marked and should be easily recognized by entomologists.

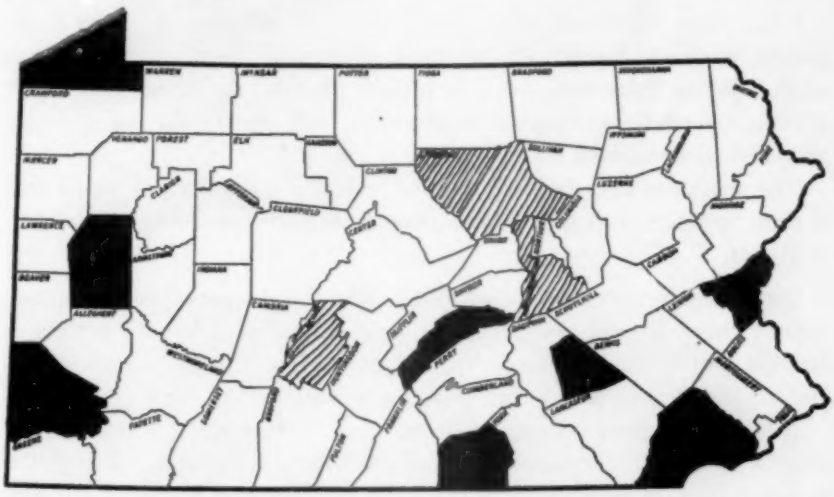


FIG. 81.—Distribution of *Stenoma algidella* Walk., in Pennsylvania; black areas indicate abundance, obliquely lined areas scarcity.

FOOD PLANTS AND NATURE OF INJURY.—*Stenoma algidella* Walk., feeds on maple, apple and various trees and shrubs. The writer was the first to record it as a feeder on apple. There is no doubt that apple is a favorite food plant in cultivated areas.

The larvae attack both the foliage and fruit of apple. They chew large holes in the leaves, sometimes skeletonizing them. On the fruit, they make large deep cavities. They have a habit of feeding between two adjacent leaves, or fastening a leaf to a fruit and feeding between them. They are abundant spinners and fasten the leaves together with broad bands of silk.

RELATED SPECIES.—The genus Stenoma apparently originated in South America where there is a large number of species. In North America there are scarcely a dozen species and these occur largely in southern United States. Aside from *algidella* Walk., and a closely related species *schlae-*

geri Zell., they are recorded chiefly from Carolina, Georgia, Florida, Texas, Arizona and California. The North American species are known to feed chiefly on forest and shade trees, as: the oaks, maple and laurel, although one species, *Stenoma ministrella* Busck, has been found on timothy. They apparently have a leaning towards fruits or seeds. Exotic species are known to feed on avocado, custard apple (Anona) and coffee. Dyar (1902) (1) gives much information on the synonymy and distribution of these species.

LIGHT AND TRAP RECORDS. The writer has occasionally taken *S. algidella* Walk., in liquid baits operated principally for the oriental fruit moth. When baits were hung in apple orchards, the numbers of adult *Stenoma algidella* were more numerous. It is apparently not strongly attracted to sweetened baits.

The species is also slightly attracted to lights. Forbes (4) noted that it came to lights on June 18, and August 22, 1919, and August 9, 1922, at Ithaca, N. Y.

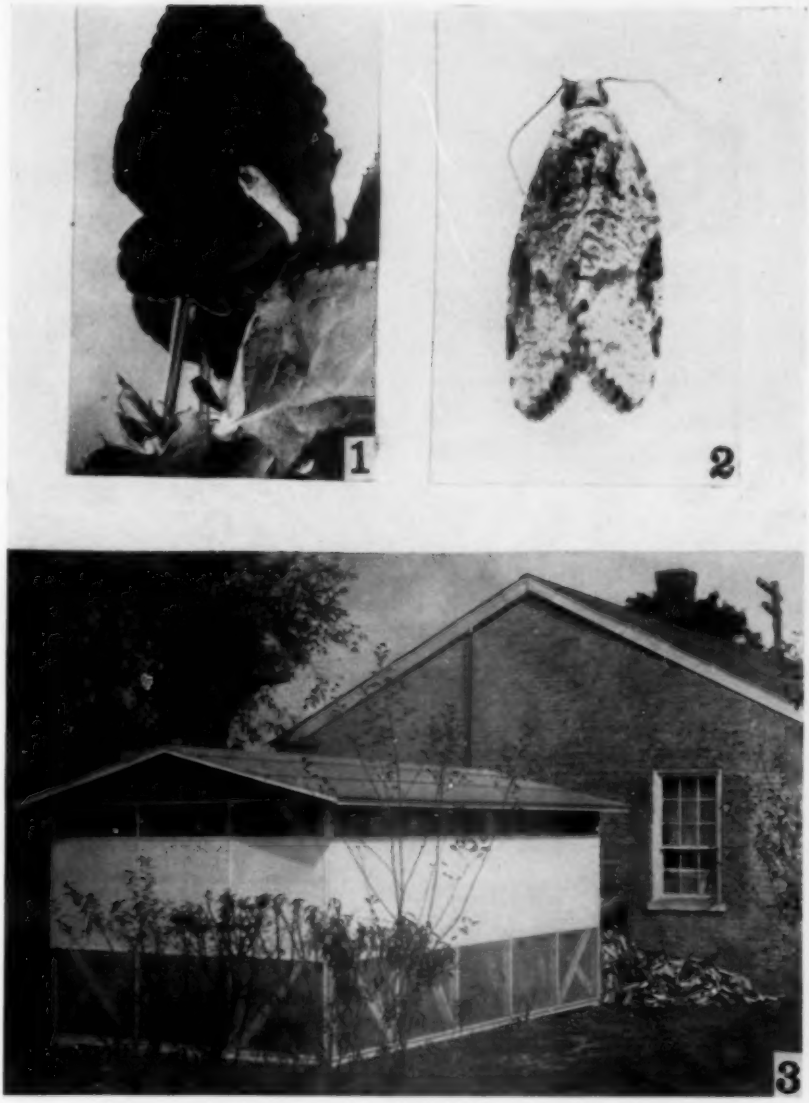
LIFE HISTORY.—*Stenoma algidella* Walk., hibernates as pupae and usually there is only one complete generation. No definite cocoon is formed, but the naked pupae are suspended by broad bands of silk in curled dried leaves where they pass the winter.

Adults commence emerging from their winter quarters about the first of May and the maximum emergence generally occurs during the first fifteen days of this month. Variations have been noted. On April 26, 1923 a single adult was seen flying in an orchard. On rare occasions overwintering individuals emerged as late as June 1.

The females commence laying eggs shortly after they emerge. One female laid eggs the day after emerging, but the majority do not start laying for two or three days. Their reproductive capacity apparently is small. One female laid 49 eggs, a second 61 eggs and a third 67 eggs.

The eggs are laid singly, or occasionally in loose groups of two or three, on the upper side of the leaf. They can be found in the orchard from about the fifteenth of May until the first of June, after that it is difficult to find them.

The first larvae pupate about June 1st, although the majority of them prolong their feeding until late in the summer, sometimes as late as September or October. Most of the pupation occurs during September or October or even the first of November. During the latter part of the summer, especially at picking time, these larvae are sometimes conspicuous feeders on the apples.



1.—Moth at rest on leaf (*Stenoma algidella* Walk.) about natural size. 2.—*Stenoma algidella* Walk., enlarged. 3.—Rearing cage or insectary at the Arendtsville Laboratory.

An occasional larva pupates in June or July and emerges the same year, producing a partial second generation. The writer gathered larvae from eleven counties in Pennsylvania during September, 1921; these were taken to the Arendtsville laboratory. They hibernated as pupae, and adults emerged during May 1922. Relatively few of these females produced larvae that pupated and emerged during 1922. The remainder pupated and did not emerge until the following year.

PUPATION RECORDS OF *Stenoma algidella* WALK.

Pupation	Adults Emerged	Pupation	Adults Emerged
*July 10, 1918	July 29, 1918	Sept. 15, 1921	May 18, 1922
Sept. 15, 1918	May 19, 1919	Sept. 17, 1921	May 16, 1922
Sept. 17, 1918	May 15, 1919	Sept. 17, 1921	May 24, 1922
Sept. 22, 1918	May 27, 1919	Oct. 3, 1921	May 25, 1922
Sept. 24, 1918	May 15, 1919	Oct. 11, 1921	May 29, 1922
Sept. 26, 1918	May 27, 1919	July 12, 1922	May 15, 1923
Sept. 27, 1918	May 27, 1919	July 13, 1922	May 7, 1923
Oct. 11, 1918	May 26, 1919	July 13, 1922	May 14, 1923
Oct. 11, 1918	May 26, 1919	July 13, 1922	May 15, 1923
Oct. 26, 1918	May 27, 1919	July 15, 1922	May 16, 1923
Oct. 27, 1918	May 26, 1919	July 16, 1922	May 16, 1923
Oct. 29, 1918	May 20, 1919	July 17, 1922	May 16, 1923
Sept. 10, 1921	May 17, 1922	July 19, 1922	May 17, 1923
Sept. 11, 1921	May 25, 1922	*July 31, 1922	Aug. 19, 1922
Sept. 12, 1921	May 13, 1922	July 26, 1922	May 15, 1923
Sept. 13, 1921	May 25, 1922	Aug. 4, 1922	May 15, 1923
Sept. 14, 1921	May 17, 1922		

DESCRIPTIONS

EGGS. Individual eggs are 1 mm. long and .5 mm. wide, pale yellow, cylindrical, pointed at one end and rounded at the other. They are laid singly or in groups of two or three on the upper side of the leaf. They have no protective covering like the eggs of leaf-rollers, that are laid in masses.

LARVA. The first stage larva is about 1.5 mm. long, pale yellowish green, with two brown or blackish spots on the upper outer edges of each abdominal segment forming a double row of spots down each side of the dorsum of the larva. The head and thorax lack the characteristic marks of the mature larva.

After the first moult, spots somewhat resembling those of the mature larva, appear on the thorax, but the head is still green, or slightly brown, with only faint darker markings.

The mature larva measures from ¾ to 1 inch long, is pale green and lacks the spots present on the abdomen of the first stage larva, but is conspicuously marked on the head and thorax with dark brown or black. (See figure 82.) Only the primary setae are present and these are long and yellow in color. The setae on the head are somewhat reduced in number.

PUPA. The pupa is 5/16 inch long, conspicuously short and broad, and is light brown. The antennae and third tarsi reach to the posterior edge of the wing pads; the first tarsi reach about three-quarters of the way to the point where the antennae meet along the middle of the pupa; the anterior spiracles are conspicuous; the eyes

are not conspicuous; the labrum and labial palpi are more evident in the female than in the female, being somewhat obscured by the clypeus in the female; six ab-

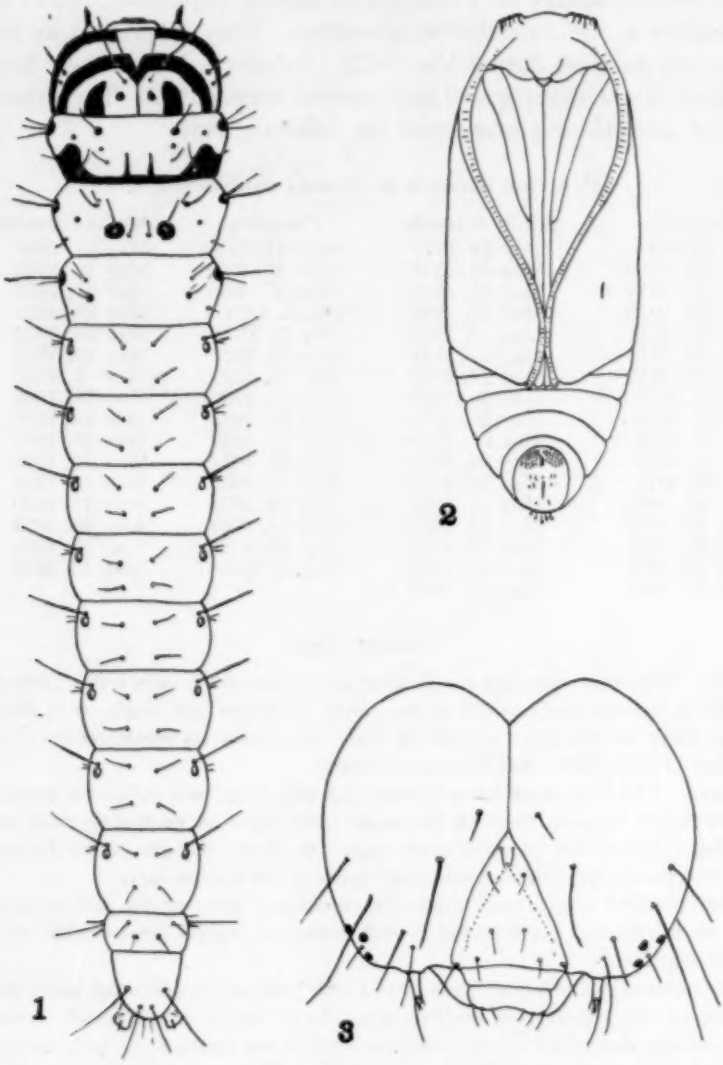


FIG. 82.—Larva *Stenoma algidella* Walk.; 2.—Pupa *Stenoma algidella* Walk, male; 3.—Arrangement of setae on head of larvae of *Stenoma algidella.*

dominal segments are visible and the last segment is beset with numerous spines and hooks, especially two rounded patches of hooks one on each side of the median line.

ADULT. The adult has a wing expanse from ¾ to 1 inch. It is predominantly white in color; the fore wings are almost pure white with gray markings, while the posterior wings are pale gray with white marginal fringes. The thorax has a prominent posterior tuft. It is conspicuous when flying but not when at rest on the foliage for it looks unlike a moth.

PARASITES AND PREDACEOUS ENEMIES

The adults are well protected against birds and other animals because, when at rest on the leaves, they resemble bird droppings. No predaceous enemies of the larvae have been observed or reported.

The writer reared four parasites[2] from the larvae of *Stenoma algidella*. *Comedo orgyiae* (Fitch) was bred from the larva. About twenty-five Comedo parasites emerged from a single host larva and formed their black cocoons in a circle, like little grave stones, about the dead larva of Stenoma.

Thirteen specimens of *Syntomosphyrum esurus* Riley, were reared from a single pupa on August 7, 1919. This parasite has been recorded previously from the pupa of the well-marked tussock moth, the fall webworm and from the galls of Trypeta on Ambrosia.

Eight specimens of *Elachertus proteoteratis* How., were reared from a single larva of *Stenoma algidella* on August 8, 1918. Previously this parasite has been recorded only from one of the Eucosomidae, *Proteoteras aesculana*.

A tachinid has been reared from the pupa of *S. algidella* and turned over to the National Museum for identification.

CONTROL.—The standard spray schedule seems to hold this insect in check. Sprays of arsenate of lead during May are more advantageous because, at this time, the largest number of larvae are present. Later in the season the larvae hide away in curled leaves, and it is more difficult to reach them.

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[2]The Hymenopterous parasites were determined by A. B. Gahan, U. S. National Museum, Washington, D. C., whose cooperation is gratefully acknowledged.

THE MORE IMPORTANT SPECIES OF LEAFHOPPERS AFFECTING THE APPLE

By DWIGHT M. DELONG, *Ohio State University*

ABSTRACT

At least twelve species of leafhoppers may become important pests of apple in one or more areas of the United States. The largest number of species occur in the Ohio and Central Mississippi valleys. They can be distinguished by color markings and male genital characters. The biology and overwintering stage will vary with the species. Some pass the winter as adults in hibernation and some as eggs in the plant tissue.

This subject has been discussed by several different workers from widely different localities and frequently from different points of view. In spite of this fact there still remains a considerable amount of uncertainty in regard to the number of species of leafhoppers which are important in one or more general areas upon apple and what to call them.

This is probably due in part, at least, to the fact that previous workers who have discussed the apple leafhoppers, while contributing decidedly to our knowledge of this subject, did not consider the problem as a unit and in some cases were thinking in terms of species belonging to certain genera rather than the populations as they occur upon the apple trees. For instance, Lathrop (6) 1918 discussed three of these species, Childs (3) 1918 discussed one and Ball (1) 1924 discussed especially the synonymy and scientific names of three species occurring upon apple. Later the work of Stearns (10) 1928 and Schoene (11) 1930 have given some idea of the importance of other species not previously mentioned as apple pests. Also the work upon certain genera containing these economic species performed by Robinson (9) 1926, McAtee (8) 1926 and DeLong (5) 1931 have helped to more accurately identify and recognize them.

Certain of these workers have stated that there are "three and only three species" or that they are confined "to certain genera" which has only added to the confusion. In this way the literature upon this subject has become filled with confused names and statements. Also due to our previous lack of taxonomic characters several of these species have been misidentified from time to time.

In view of this fact it has been customary for economic entomologists to refer to any one of the several common species of abundant leafhoppers feeding upon apple as "the apple leafhopper." Recent text books on economic entomology have followed the same idea and have attempted

to discuss the subject, "the apple leafhopper." In some cases these discussions have not only failed to treat the more important economic species but have confused the biology or the name of one species with that of another. The present treatment is an attempt to report upon observations made during the past five years in different areas of the

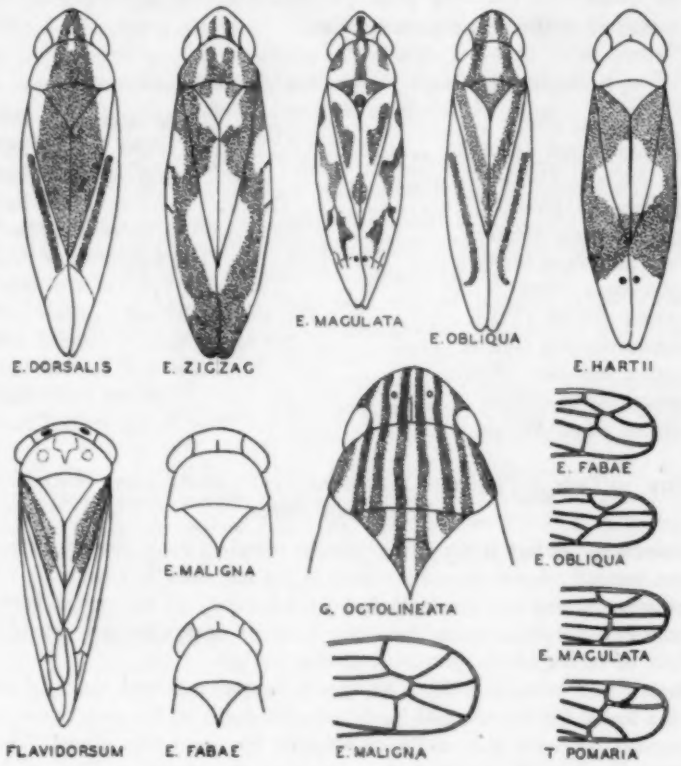

FIG. 83.—Color patterns of well marked species and wing venation of closely related genera.

United States and deals entirely with the different species concerned, their recognition and biology.

There are several species of apple leafhoppers and they belong to several genera. In addition a large number of species not discussed here are commonly found upon apple incidentally, many of which are grass feeding forms. Those which live upon apple and usually become pests in one or more of the apple growing areas are listed below, together with suggested common names. In reporting the occurrence or preva-

lence of certain species of apple leafhoppers, it has seemed advisable to devise some way of designating those of greatest importance. As a consequence the following common names are suggested in an attempt to further qualify the "apple leafhopper"name. Such a system of names is of interest to Mr. J. A. Hyslop for use by the various workers reporting in projects like the crop pest survey. He has approved these suggested names for the respective species.

SUGGESTED COMMON NAMES FOR APPLE LEAFHOPPERS

Gypona octolineata (Say)	The large apple leafhopper
Idiocerus flavidorsum (A. & S.)	The yellow backed leafhopper
Empoasca maligna (Walsh)	The green apple leafhopper.
Empoasca fabae (Harris)	The potato leafhopper
Typhlocyba pomaria McAtee	The white apple leafhopper.
Typhlocyba xanthippe McAtee	The yellow apple leafhopper.
Typhlocyba rosae (Linn)	The rose leafhopper.
Erythroneura obliqua (Say)	The oblique striped (apple) leafhopper
Erythroneura dorsalis Gillette	The broad striped (apple) leahopper.
Erythroneura maculata Gillette	The red spotted leafhopper.
Erythroneura hartii Gillette	The red apple leafhopper.
Erythroneura ziczac Walsh	The zigzag striped leafhopper.

HOW TO DISTINGUISH THE SPECIES OF LEAFHOPPERS THAT NORMALLY LIVE UPON APPLE

Gypona octolineata Say is the largest species found on apple about 8–10 mm. long. It is dorso ventrally flattened and the head is flat and broadly rounded. The ocelli are usually bright red and are located about the middle of the vertex between the eyes. In well colored specimens there are 8 red or orange stripes extending from the margin of vertex across pronotum onto scutellum.

Idiocerus flavidorsum A & S. This species is wedge shaped about 5.5 mm. long and with a broad bluntly rounded head and with ocelli on the face below the margin of vertex. It is the only apple species with the ocelli thus placed. This insect is chestnut brown with bright yellow areas on the claval portions of the wing (anal cells) at the sides and just back of the scutellum.

Although the species of Empoasca Typhlocyba and Erythroneura occurring on apple can usually be separated, with few exceptions, rather well by color or other characters, if difficulty should arise the characters on the wing as illustrated will give the generic separation rather easily. As a rule the species of Empoasca are rather bright green, the species of Typhlocyba white or pale yellow unmarked and the species of Erythroneura white with conspicuous color markings. Sometimes these markings are only faintly visible and if so the wing character can be used for generic separation.

Empoasca maligna Walsh. Bright green with a broadly rounded head. The male plates are long and fingerlike, very narrow with upturned tips. The female segment is obliquely notched either side of a sunken median tooth.

Empoasca fabae Harris. Narrower and appearing smaller than maligna. The head is blunt but more produced than in maligna. Bright green in color usually with a row of small white dots along anterior margin of pronotum. The female segment is entire and roundingly produced. The male plates are triangular, strongly upturned posteriorly, and thickly set with long green spines.

The species of Typhlocyba are much more difficult to separate externally than species of the other genera. The male genital pieces as illustrated (Fig. 84) are by far the best characters for identification.

Typhlocyba pomaria McAtee. White or pale yellow without markings. By exposing the external genital structures of the male the long black ventrally pointed spines of pygophers can usually be seen and will easily distinguish this species. The long dorsally pointed oedagus is also an excellent character. It usually projects between the two ventrally pointed spines.

Typhlocyba xanthippe McAtee. Slightly smaller than *pomaria* and more yellowish. The spines of the pygopher are missing but it can be distinguished from rosae only by the character of the oedagus. The dorsal terminal portion of the oedagus has a pair of anteriorly produced processes which are upwardly concavely curved and a process which curves downward between them.

Typhlocyba rosae Linn. Size and appearance of *pomaria*, white in color. The terminal portion of the oedagus has four leaf like processes which project anteriorly. This character will easily distinguish it from the other apple forms of Typhlocyba.

Erythroneura obliqua Say. Pale with two red or orange stripes extending across vertex pronotum and scutellum and with four red or orange oblique stripes on the wings. The anterior pair are on the outer portion of the clavus and merge at the tip of the clavus. The posterior pair reach from near the costa to the apical cross veins. These markings are sometimes very faint but the internal genital characters as shown in the accompanying figure will always correctly identify the species.

Erythroneura dorsalis Gillette. Easily distinguished by the broad red or dark colored stripe extending from anterior portion of vertex across pronotum, scutellum and calvus of elytra. A pair of oblique stripes just posterior to claval vein and parallel to it are often fused with the solid color pattern of the clavus. Internal male genital characters are shown in Figure 84.

Erythroneura maculata Gillette. Pale with red markings in the form of spots or blotches. A mediam red stripe extends across vertex and pronotum. A red spot behind either eye on pronotum. Scutellum with a reddish spot in each basal angle and a round spot at apex. Elytra with a red blotch along inner margin of claval vein either side and a red spot at tip of clavus. A series of three or four spots more or less contiguous extending from anterior margin of costa to apical cross veins. A pair of round black spots on inner margins of wings at apical cross veins.

Erythroneura hartii Gillette. Vertex, pronotum and scutellum white or pale yellow. Wings bright red to apical cross veins except a large almost octagonal area extending across the center of the inner margins where folded. A pair of large round black spots on inner margins just back of cross veins. This is a conspicuous species not easily confused with any other on the apple. The internal genital character is included for certain identification.

Erythroneura zicsac Gillette. Somewhat variable in both shade and extent of coloration. Vertex usually with a pair of color markings on posterior portion.

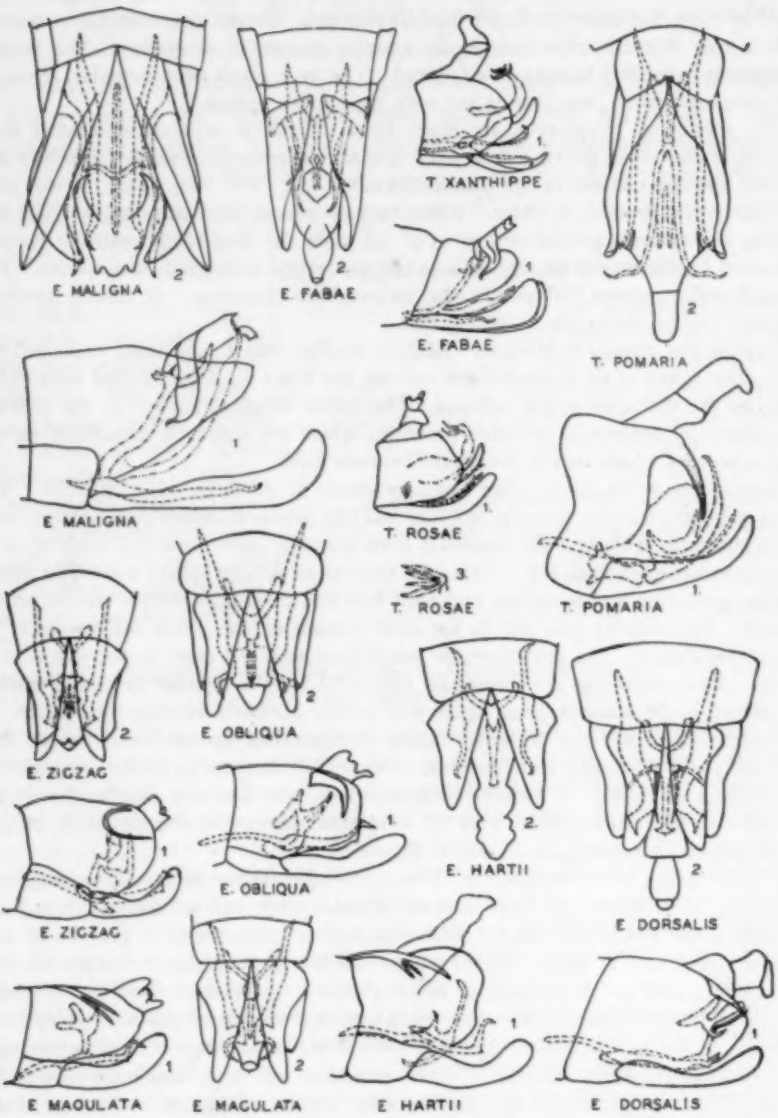

FIG. 84.—Internal male genital characters of species of Empoasca, Typhlocyba and Erythroneura infesting apple. 1. Lateral view; 2. Ventral view; 3. Terminal portion of oedagus.

Pronotum with a central area and one just back of either eye. Wings with a pair of zigzag bands or stripes extending from outer costa at the base to inner clavus behind the scutellum then curving to apical cross veins and covering the apices of the wings. The genital structures used for identification are illustrated.

Biology and Seasonal Cycle

A comparison of the seasonal cycles of the various species concerned shows that *Gypona octolineata* has a single generation with an overwintering egg stage. The adults appear early in July and remain throughout the season. Observations in Ohio have shown that the eggs hatch in May and early June. The nymphs feed upon the apple during the first and sometimes part of the second instar. Under normal conditions they then leave the apple and live upon herbaceous plants until late summer or autumn when they again return to the apple and lay eggs in the new twigs. The egg punctures are the largest produced by any leafhopper infesting the apple and frequently approach in size those of the Buffalo treehopper. They are laid singly and usually five to seven in a row end to end along the twig, but separated from each other by a distance about equal to the length of the puncture scar on the bark. Very little if any economic injury results from feeding but a large amount of injury is caused by the egg puctures, especially upon young trees.

Idiocerus flavidorsum has practically the same cycle as the previously mentioned species and overwinters as an egg in the twigs. It hatches in late May or early June and has a one generation cycle. This is only a minor pest of apples but in southern Ohio frequently occurs in good numbers.

The genus *Empoasca* contains two species frequently important as pests upon apple. *E. maligna* is the true apple *Empoasca* and overwinters upon the apple in the egg stage, hatching in the latter half of May. In many areas it is a serious pest to apple foliage. There is one generation a year and the eggs are laid in the late summer or autumn. *E. fabae,* the potato leafhopper, is more frequently a pest upon young fruit trees or young tender foliage. Although a considerable amount of biologic work has been performed on this species, attempts to carry it through hibernation have thus far been unsuccessful. When it appears upon economic plants in the spring, it is in the adult stage and this is not until late May or early June while all known forms of hibernating leafhoppers appear in April or early May in the same area. A closely related species, *E. erigeron,* is known to hibernate in the egg stage upon

wild host plants and to hatch early in May. It completes its first brood by the time *E. fabae* is migrating to potato. In view of these facts and conditions it is quite possible that *fabae* may be found to have a wild

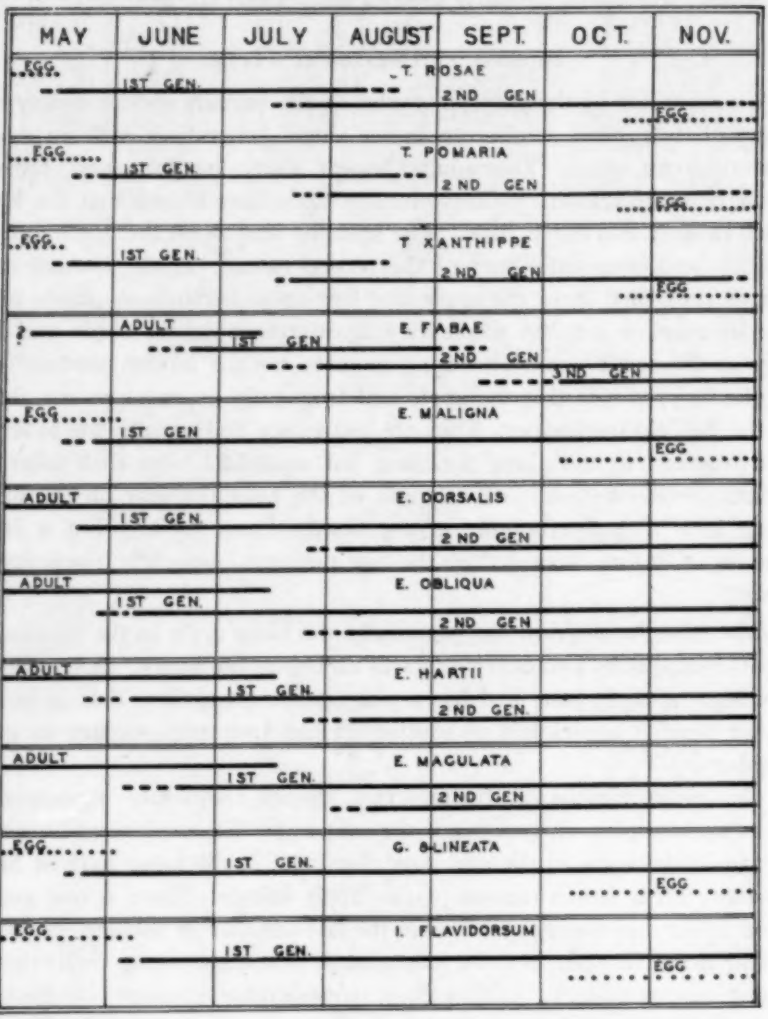

FIG. 85.—Diagrammatic seasonal cycles of the apple leafhoppers.

host plant upon which it winters as an egg. But search and study have not revealed the same to date.

There is also a possibility, because of the late appearance of this insect in the spring, that it is able to winter only in areas farther south and

that it migrates in the spring to the northern states. All the data collected and observations made upon the three possibilities would indicate that the last is probably the most logical theory.

Three species of the Genus *Typhlocyba* may occur upon apple. These are *T. pomaria, xanthippe,* and *rosae.* For many years *rosae* was considered the important species of this genus occurring upon apple. Now we find that this was misidentified and *rosae* is only an occasional incidental inhabitant of apple. *T. pomaria* is the most common and widespread species of this genus occurring upon apple. In the eastern U. S. *T. xanthippe* becomes very abundant in certain areas and is a serious pest.

It is apparent that previous records of *rosae* in abundance are in error and observations in areas where *rosae* was previously reported have shown either *pomaria* or *xanthippe* to be the important species. The species reported by Childs as *rosae* is apparently *pomaria* since that is the important species of *Typhlocyba* occurring in that area according to recent observations.

The life cycles of these three species are very similar. Each overwinters in the egg stage, hatching about the middle of May and each has two generations a season in Ohio. The life cycle of *xanthippe* and *rosae* are almost exactly alike regarding time of spring hatching and development except that *xanthippe* normally occurs upon apple and *rosae* upon the rose.

It is probable that several species of *Erythroneura* may at times become abundant upon apple. Of the five that are being treated in this discussion, the life cycles of four are rather well known. *E. dorsalis, E. obliqua, E. hartii* and *E. maculata* hibernate as adults in fallen leaves and are frequently out of hibernation as early as March or April during warm days. As soon as there is sufficient succulent foliage they are abundant upon many shrubby plants and vines. They become abundant upon apple as soon as the leaves appear and the eggs are usually laid in late May or early June depending upon the season. Two generations are normally produced in the case of each of these species. The eggs for the second generation are laid in late July or early August.

The detailed biology and the comparative life cycles are shown by the accompanying diagram.

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THE LIFE HISTORY OF THE CALIFORNIA RED SCALE *CHRYSOMPHALUS AURANTII* MASKELL: PROGRESS REPORT

By C. I. BLISS, B. M. BROADBENT, and S. A. WATSON, *Bureau of Entomology, United States Department of Agriculture*

ABSTRACT

This progress report is restricted to three phases in a study of the life history of the California red scale. Daily observations on field-collected adults on green lemon fruits indicated an average productivity of from 85 to 90 crawlers per female. When plotted against mean temperatures, the duration of the first instar was least dependent upon temperature, the length of the third stage the most. Natural mortality following settling was greater in the last than in the first two instars, and during the winter approached 100 per cent.

Over twenty years ago Prof. H. J. Quayle[1] made a careful study of the life history of the red scale in southern California, doing most of the work at Whittier, 13 miles east of Los Angeles. Since then the scale infesting this region has shown an increased resistance to killing with hydrocyanic acid gas, either through a selective change in the original population or through a replacement of the original infestation by a resistant strain spreading from some other locality. It was thought,

[1]Quayle, H. J. The Red or Orange Scale. Calif. Agr. Expt. Sta. Bul. 222: 99–150. 1911.

therefore, that another study of the life history in the same region might reveal biological differences paralleling the change in its toxicological behavior. This investigation was started in July, 1930, and will be continued for at least another season. Hence this paper is only a report of progress. It will be restricted to three topics: (1) The productivity of field-collected adults, (2) the length of development of the female as related to mean temperature, and (3) seasonal changes in mortality.

PLANT FOOD.—The material was reared in an open, screened, and roofed insectary on the laboratory grounds. Conditions of temperature and humidity in this insectary approximated those obtaining in near-by citrus groves, although the light intensity was less, at least in comparison with the most exposed parts of the tree. A hygrothermograph in the center of the insectary supplied temperature records from which means were secured with a planimeter. Green lemons were the principal source of food. These were cut with long stems when two-thirds to three-fourths grown and kept in water or nutrient solution. Although they partially dried out after two or three months, this did not seem to increase the mortality of the scale. In the last instar, when such an effect should be most marked, there was a higher mortality, as well as a slower development, upon growing rooted seedlings than on these lemons. Hence the lemons may be considered provisionally as no less favorable a food than fruit on the tree.

PRODUCTIVITY OF ADULTS COLLECTED IN THE FIELD.—For records on productivity infested lemons were brought into the insectary. Though the red scale is a viviparous insect, the newly emerged crawlers remain ordinarily a day or longer beneath the parent scale covering before going outside. In order that daily records of actual production might be obtained, females were prepared for observation by cutting away the scale covering from over the pygidium so that a clear view could be obtained of the crawlers as they emerged. An individual cage, made from a gelatin capsule with one end cut off and attached to the lemon with gold size, was placed over each female. This confined the crawlers and yet permitted unobstructed observation by removing the perforated top of the capsule.

Many females were caged and checked daily for production. If crawlers appeared within the first two days, a female was assumed to have started production before caging and she was discarded. Forty-three females met the requirements, starting production between July 25 and August 18, 1930. Their histories were followed until three days after production stopped, when each was cleared and mounted on a

microscope slide for determination of the number of embryos still remaining in the body.

The results have been summarized in Table 1, together with the earlier work by Professor Quayle for comparison.[1] Although the writers found a shorter period of productivity, the average daily production was enough greater to increase the total number by nearly a third over the value determined 20 years ago. If it is assumed that undisturbed females in the grove produce ordinarily one-third to one-half of the embryos found in various stages of development in the body after death, the expected normal production will be between 85 and 90 per female instead of 55 as found by Quayle. Though the race may have changed biologically, the writers attribute the greater productivity in 1930 primarily to two factors: (1) Their observations were made on females obtained from field infestations on lemon fruits, whereas Professor Quayle used leaves for rearing his material; (2) the two investigations were made at different seasons of the year. It is clear, however, that the reproductive capacity of this insect is greater at the present time than is indicated by Professor Quayle.

TABLE 1. PRODUCTIVITY OF THE CALIFORNIA RED SCALE AT WHITTIER, CALIF., IN 1910 AND IN 1930

	Quayle,[1] Sept. 20 to Nov. 21, 1910, 14 females fed on citrus leaves	Bliss, Broadbent, and Watson, July 25, to Sept. 29, 1930, 43 females fed on lemon fruits			
	Mean	Mean	Standard Deviation	Minimum	Maximum
Production period, in days	23.6	18.3	10.8	5	52
Number of crawlers produced daily	2.3	4.0	2.6	0	14
Total number of crawlers produced	55.1	72.6	33.3	18	176
Number of embryos remaining in female	—	42.5	13.6	6	72

[1]Op. cit., p. 122.

EFFECT OF TEMPERATURE ON DEVELOPMENT OF THE FEMALE.—Before discussing the effect of temperature upon development, it will be well to describe the developmental stages of the red scale. The first instar begins with the permanent settling of the active crawler and the start of secretion of the scale cover. Shortly after the first molt the sexes become distinguishable, the females growing through a second molt to become more or less circular, formless, producing adults, the males elongating and after three molts reaching the winged stage. The first instar, therefore, includes both sexes in nearly equal proportions. The ends of

both first and second instars are timed at the completion of the respective molts. The third instar is considered to be the period between

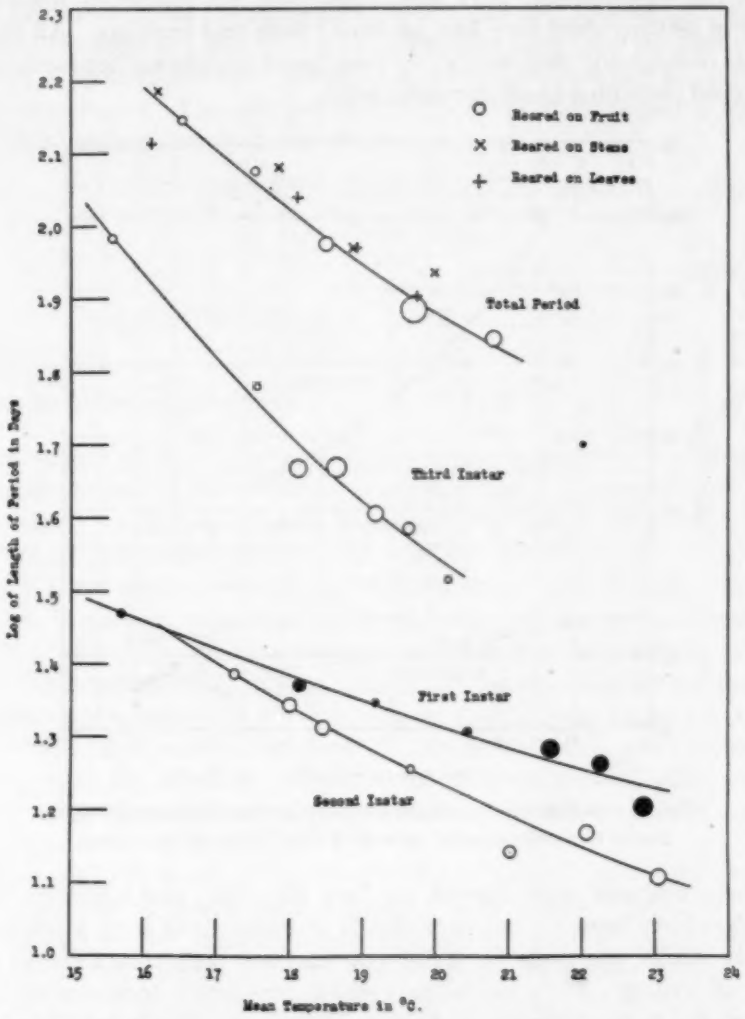

FIG. 86.—Relation between temperature (degrees centigrade) and logarithm of length of developmental periods of the California red scale.

the completion of the second molt and the first appearance of a crawler outside the parent scale covering. It therefore includes the final developmental phase of the female, the embryonic development of her first eggs, and the period of hesitancy beginning with the rupture of the

egg membrane and ending when the first-born crawl out from under, which is the starting point for the next generation.

In the experimental work the scales were not disturbed from the time of settling until they had produced their first crawlers. All judgments of stage and molt conditions were based on external appearance as observed through a binocular microscope.

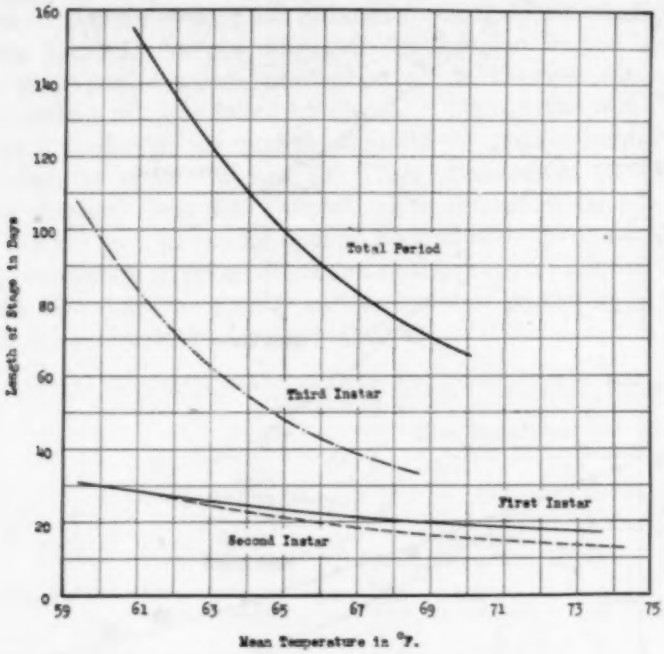

FIG. 87.—Relation between temperature (degrees Fahrenheit) and length of developmental periods of the California red scale.

These rearings were started on July 25, 1930, and although new crawlers have been set out periodically at intervals of from a few days to two weeks, the cycle for a full year had not been completed at the time of writing. Only individuals which completed development and reproduced were considered in drawing the curves. The logarithm of the length of the development period has been plotted against the mean temperature in Figure 86, the diameter of the circle being proportional to the square root of the number of cases. By this method of plotting, the proportional effect of temperature upon development can be gauged directly from the relative slopes of the curves. The first instar was of longer duration than the second, but the third instar exceeded in length

that of the other two combined. A change in temperature had the least effect upon the first instar, greater effect upon the second stage, and the greatest effect upon the combined third instar and accessories. In all instars development was more rapid upon fruit than upon the stems and leaves of potted seedlings. Leaves seemed to be somewhat more favorable than stems. The combined effect upon the whole period is shown in the uppermost curve of Figure 86.

TABLE 2. MORTALITY OF THE CALIFORNIA RED SCALE REARED IN SCREENED INSECTARY AT WHITTIER, CALIF., WHICH SETTLED FROM JULY 25 TO AUGUST 29, 1930

Stage of Development	On Lemon Fruits		On Citrus Seedlings	
	Number Settled	Per cent Died	Number Settled	Per cent Died
First	501	9.8	177	5.1
Second, female	220	7.3	77	9.1
Third, female	201	18.9	64	34.4
Whole developmental period	—	33	—	43

For practical use the curves of Figure 86 may be replotted by using the natural numbers as ordinates and the temperatures converted to degrees Fahrenheit for comparison with Weather Bureau data. (Fig. 87.) Using the normal temperatures for the nearest station, Los Angeles, we would expect three generations a year, judging from these curves. Under shaded conditions this is probably correct. In the grove, however, radiant heat from direct sunshine may raise the temperature of exposed insects materially above that of the air as measured by shaded thermometers, hastening development, or sunlight may cause an earlier emergence of crawlers from beneath the parent scale covering quite apart from the effect of temperature. Both of these factors might shorten development sufficiently to allow a fourth or partial fourth generation.

SEASONAL VARIATIONS IN MORTALITY.—Natural mortality in the rearing material varied with stage and with season. Because only the more vigorous crawlers were selected for rearing, the mortality records exclude stages prior to the successful formation of the scale covering. Table 2 gives a comparison of the death rate in the different stages for individuals which settled from July 25 to August 29, 1930, a period of relatively uniform, low mortality. Lemon fruits seemed to be somewhat more favorable than leaves or stems, and in both cases the mortality following settling was heaviest in the last instar.

As winter approached mortality increased markedly. Thus, beginning in early September there was a mounting mortality which by the end of the month reached 90 per cent of those which settled. (Fig. 88.)

Practically none of the new scales settling later than October managed to reach the adult stage and reproduce. This excessive mortality continued until late winter. However, it probably was somewhat greater than in the field, for the writers were able to collect in the orchards producing females with freshly emerged crawlers throughout the winter.

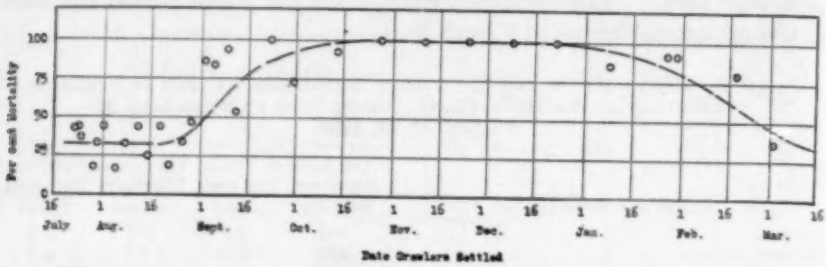

FIG. 88.—Effect of season upon mortality of female stages following settling of crawlers of the California red scale.

SUMMARY AND CONCLUSIONS

Studies on the life history of the California red scale in an outdoor screened insectary at Whittier, Calif., have reached a stage where a report of progress is justified.

Field-collected adult females on green lemon fruits produced an average total of 73 crawlers, but at the time of death they contained a mean number of 42 embryos in various stages of development. Some of these should probably be added to the expected total productivity.

The length of the three female instars when reared upon green lemon fruits, cut with stem, was somewhat shorter than that of others reared on potted seedlings. The length of each instar was dependent primarily upon the average mean temperature. The effect of temperature was least marked in the first instar and most important in the third, a stage which was defined to cover the period from the termination of the second molt to the first appearance of crawlers outside the female scale covering. On the basis of the curves relating development to temperature and the normal temperatures for Los Angeles (the nearest station of the Weather Bureau), three generations a year would be expected for scales developing under shaded conditions equivalent to those in the insectary.

Natural mortality following settling was greater in the last instar than in the two earlier stages. For individuals starting development in late summer, it averaged during the entire developmental period 33 per cent on lemon fruits and 43 per cent on citrus seedlings. Scales

which settled in September and later in the season showed an increasing mortality as winter approached, which equaled 100 per cent for those starting development in November and December. In the spring the mortality decreased.

FEEDING TESTS OF ANOPHELINE MOSQUITOES WITH LEGUMINOUS PLANTS

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ABSTRACT

The data here given seem to indicate that mosquitoes do not feed to any extent on either the blooms or foliage of legumes; that legumes are not attractive to mosquitoes; and that when confined in cages with legumes, mosquitoes obtain little if any sustenance from the plants.

Even if we admit that coumarin can disinfect malaria-infected mosquitoes, it would appear that, in the case of our principal malaria vector, *A. quadrimaculatus* Say, at least, there is little likelihood of its ever obtaining this substance by feeding on legumes.

Considerable interest has been aroused by the contention of Willcocks[1] and D'Herelle[2] that the absence of malaria in cultivated Egypt is due to the extensive cultivation in that country of clovers and other legumes, which contain a substance, coumarin, which it is claimed may be capable of disinfecting mosquitoes which become infected with the malaria parasite, or make the mosquitoes incapable of becoming infected. In order to test a part of this theory, a few experiments were made at the Mound, Louisiana, Laboratory of the Bureau to determine whether or not mosquitoes would actually feed on leguminous plants and flowers when available and, if so, whether they could sustain themselves for any considerable period on that medium. These experiments were carried out under the direction of F. C. Bishopp by W. V. King and the writer.

For experimental purposes short rows of seven kinds of legumes were planted at Mound, all of which grew luxuriantly. These were *Melilotus officinalis*, *M. indica*, *M. suaveolens*, *M. alba*, *M. annua*, *Trifolium alexandrinum*, and *Trigonella foenum-graecum*. Legumes, both wild and cultivated, grow abundantly in the districts about Mound, white clover being particularly common and covering pastures and wasteland with

[1]Why is cultivated Egypt immune from malaria? By Sir William Willcocks, K. C. M. G. The Nile Mission Press, Cairo, December, 1927.

[2]D'Herelle. Immunity in natural infectious diseases. (Quoted in 1 above).

its blooms in the spring. Malaria is also very common. While the experiments were in progress, both during the day and at night, the mosquitoes were, from time to time, observed in their reactions toward the plants. None was seen actually to feed on them. In some miscellaneous tests, however, individuals were seen on two or three occasions to be nervously probing around on or licking the surfaces of leaves and flowers as if wanting to feed, but finding nothing to their liking. The mosquitoes appeared to prefer to rest on the sides or top of a cage rather than on the clover foliage, indicating that the plant was not particularly attractive to them.

TABLE 1. AVERAGE LENGTH OF LIFE OF *Anopheles quadrimaculatus* IN SCREENED CAGES WITH AND WITHOUT LEGUMES FOR FEEDING

Exp. No.	Date Started	Mean Temp.	Average Number of Mosquitoes per Cage	Average Life of Mosquitoes				
				Legume cages[1]			Check Cages[1]	
				Melilotus officinalis	M. alba	M. suaveolens	Raisins	Cotton
	1929	°F.		*Hours*	*Hours*	*Hours*	*Hours*	*Hours*
10303	Aug. 24	80.5	2 males 5 females	46	50	44	63+	42
10304	Aug. 27	78.5	4 females	22	31	29	60+	16
10305	Aug. 30	75.8	5 females	20	39	31	65+	47
10306	Sept. 5	82.0	5 females	53	24	22	32+	24
10307	Sept. 7	82.0	5 females	—	42	42	56+	49
10308	Sept. 12	76.0	1 male 7 females	54	66	54	118+	50
Average.....		79.1		39	42	37	66+	38

[1]Wet cotton placed in each cage.

Table 1 gives the record of six experiments to determine the effect of legumes on mosquitoes, in which known numbers of *Anopheles quadrimaculatus* Say were confined in small screened cages, 8 inches by 10 inches by 10 inches. Three of these cages contained sprigs of leaves and blossoms of different species of clover which were kept fresh by being set in vials of water; one contained raisins, and one contained wet cotton only. A vial filled with water and plugged with absorbent cotton, which served as a wick and kept the water always available, was placed in each cage. The mosquitoes used in the tests were collected from hollow trees near breeding places. Only those individuals which appeared to be freshly emerged and which showed no evidence of having had a blood meal were placed in the cages.

This table shows that the average life of the mosquitoes was not appreciably longer in the presence of legumes than it was in the presence of wet cotton alone, indicating that little if any sustenance was being derived from the legume. The figures for length of life in the check cage with raisins show that, given food, mosquitoes will live for a considerable

TABLE 2. AVERAGE LENGTH OF LIFE OF *Anopheles quadrimaculatus* IN LANTERN GLOBES WITH AND WITHOUT LEGUMES FOR FEEDING

Exp. No.	Average Number of Mosquitoes per Cage	Date Started	Mean Temp.	Average Life of Mosquitoes								
				Legume Cages						Check Cages		
				Melilotus officinalis		M. alba		M. suaveolens		Raisins	Cotton	
		1930	°F.	Dry[1] Hrs.	Wet[1] Hrs.	Dry Hrs.	Wet Hrs.	Dry Hrs.	Wet Hrs.	Wet Hrs.	Dry Hrs.	Wet Hrs.
10309	5 females	Aug. 24	80.5	42	47	47	42	42	42	76+	—	42
10310	5 females	Aug. 27	77.9	28	31	32	23	30	31	52+	—	20
10311	5 females	Aug. 30	77.2	31	39	38	43	37	41	64+	—	32
10312	5 females	Sept. 5	82.0	24	52	40	55	25	33	46+	—	34
10313	5 females	Sept. 7	82.0	52	—	—	—	35	52	—	—	30
10314	1 male 5 females	Sept. 11	76.0	36	57	23	41	40	48	98+	—	36
10315	5 females	Sept. 14	76.0	49	57	32	58	49	63	95+	43	49
Average			78.8	37	47	35	44	37	44	71+	—	35

[1]Dry means that no water was available. Wet means that water was available.

period under the conditions present in the cages. The + signs in this column mean that all mosquitoes were not dead at the time the observations were discontinued.

TABLE 3. AVERAGE LENGTH OF LIFE OF *Anopheles quadrimaculatus* IN LANTERN GLOBES WITH LEAVES OF LEGUMES ONLY AND WITH LEAVES AND BLOSSOMS OF LEGUMES

Exp. No.	Date Started	Average Number of Mosquitoes per cage	Average Life of Mosquitoes in Hours: Legume Cages: Melilotus annua: Leaves only: Wet	Leaves only: Dry	Leaves and Blossoms: Wet	Leaves and Blossoms: Dry	Check Cages: Cotton: Wet	Cotton: Dry	Raisins: Wet
	1929								
10317.....	Sept. 24	5 females	61	68	74	66	54	53	121+
10316.....	Sept. 24	5 females	91	90	57	45	[1]88	52	115+
10318.....	Sept. 23	5 females	57	52	79	37	54	63	100+
Average.....			70	70	70	49	64	56	112+

Average daily mean temperature during tests, 69.6°F.

[1]Only four individuals of *Anopheles quadrimaculatus* were used in this test. The fifth individual, which proved to be *A. punctipennis*, died in 67 hours.

Table 2 gives the record of seven experiments conducted to determine the effect of legumes on the length of life of *Anopheles quadrimaculatus* in the presence and in the absence of water. The plan of the experiments was the same as those summarized in Table 1 except that lantern globes with gauze-covered tops were used as cages, and the tests on each legume were made with and without wet cotton. The mosquitoes used were obtained in the same manner as those reported on in Table 1. The tests with the wet cotton and a legume show longer average duration of life for the mosquitoes than was shown in Table 1. This is no doubt due to the lantern globe being a more satisfactory cage for holding the insects, and possibly to a lower average mean temperature occurring during the tests. There is, however, here indicated a longer life for the mosquitoes when confined with a legume and water than with water only. This may be caused by mosquitoes getting some sustenance from the legume, or it may be caused by the presence of the legume in the globe making the humidity and possibly other conditions more suitable for mosquito life. The life of the mosquitoes averaged much shorter in the "dry" cages where there was no access to water. The check on this series of tests was run in only one case and therefore can not be discussed with the average figures for all tests. For the single experiment in which it was included it shows, except in one case, an increased life for mosquitoes in the presence of a legume. The figures for average life in the raisin check cage, as previously, show that under like conditions, except with suitable food present, the mosquitoes will live considerably longer than they will with legumes.

Table 3 gives the record of three experiments to ascertain whether or not the presence of legume blossoms influences for a longer mosquito life than the presence of leaves only. The results show no advantage in having blossoms present. The check cages show results similar to those discussed for the previous tests (Table 2).

TABLE 4. AVERAGE LENGTH OF LIFE OF FRESHLY EMERGED *Culex quinquefasciatus* IN LANTERN GLOBES WITH AND WITHOUT LEGUMES

Exp. No.	Date Started	Average Number of Mosquitoes per Cage	Average Life of Mosquitoes in Hours: Legume Cages Melilotus officinalis Wet	Legume Cages Melilotus officinalis Dry	Check Cage Cotton, Wet
	1929				
10319A	Sept. 25	1 male 3 females	46	51	53
10319B	Sept. 26	1 male 3 females	50	47	50
10319C	Sept. 26	1 male 3 females	45	45	41
Average		1 male 3 females	47	47.7	48

Average daily mean temperature during tests, 73.2°F.

Table 4 gives the record of experiments made to determine the influence of legumes in prolonging the life of freshly emerged *Culex quinquefasciatus* Say. The results show no increase in life in the presence of legumes.

Similar tests made with freshly emerged *A. quadrimaculatus* in 1930 gave similar results. As these tests were not checked frequently enough to give very satisfactory comparative records, they are not here reported on.

THE USE OF INSECTICIDES ON PINEAPPLE PLANTS IN HAWAII[1]

By WALTER CARTER

ABSTRACT

The use of oil emulsions has provided a satisfactory method of control against *Pseudococcus brevipes* Ckl. although the search for suitable parasites is being continued.

The pineapple mealy bug, *Pseudococcus brevipes* Ckl., is the most common and frequently observed species on pineapple plants in Hawaii. It can be found feeding at the bases of the tender heart leaves of the

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plant and after the fruit is formed sometimes congregates in great masses at the base of the fruit. This accumulation on fruit, particularly in old fields, attracted attention from time to time and Fullaway (1), (2), records observations on the insects and some data on the application of insecticides. Apart from damage to the fruit, no evidence was available as to the effect of the mealy bugs feeding on the plant and control by the use of insecticides was not investigated further or put into effect. During the last few years, however, observational evidence began to accumulate that *brevipes* might be a factor in pineapple wilt[2] and in 1929 some pineapple section men had begun to experiment on the effect of sprays and dusts applied at the border of the fields. Illingworth (3) presents preliminary evidence on the relationship between mealy bugs and the collapse of young pineapple plants and mentions therein that oil emulsions applied to the heart of the plant is a good control. In the spring of 1930 the writer took up the question of the relationship between mealy bugs and pineapple wilt and in (4) presents evidence on the movements of mealy bugs in young pineapple fields and the development of the populations therein. Studies on the value of insecticides were undertaken primarily as a means of maintaining check plots in field experiments on the effect of mealy bugs in producing wilt. It is recognized that with the remarkable success that biological control has achieved under Hawaiian conditions, no doubt, if *Pseudococcus brevipes* was found to be a serious pest, biological control would also be the logical method of attack in that case. In the past 10 years, however, a number of predators and some parasites have been introduced with this point of view in mind, but though a number of these have become established throughout the Islands there is no evidence that they have achieved their purpose. Explorations are being continued, however, with a hope that a suitable parasite can be found. In the meantime studies on insecticides have been carried on with a view to finding a temporary measure of relief. Experiments on the relationship between mealy bugs and edge wilt which occurs in the first ratoon must necessarily cover a long period of time since a minimum of two years must elapse between planting and the beginning of the first ratoon growth.

METHODS: Heavily infested planting material was used, principally

[2]The term "wilt" as applied to pineapples is no doubt generic and a good many factors can be assigned some measure of causality. The type of wilt of particular interest in this case was that which apparently starts at the edge of the field shortly after the plant crop, that is, the first crop, has been taken off and very much reduces the returns from the second and later ratoon crops.

slips which grow out from just below the fruit and which become heavily infested by movement of bugs from the fruit as the latter ripens. Two methods of application were used, dipping and spraying. Both were of interest since the general nature of mealy bug infestation in planting material in the fall of 1930 was occasion for considerable concern, and dipping and spraying of planting material was practiced to some extent at that time.

All the slips to be used in an experiment were set butt up on the ground and from these a random sample was taken. The individuals in this sample were dissected and all the mealy bugs thereon, counted. After the treatment was applied an interval of two days was allowed to elapse and the treated materials were similarly dissected. At the same time a second untreated sample was counted. This procedure was made necessary by the fact that movement of mealy bugs away from this planting material may occur. The usual method of counting dead and live insects separately after application of an insecticide was departed from in these tests and only live mealy bugs left on the plants after treatment, were considered. This was made necessary by the fact that the big-headed ant (*Pheidole megacephala* Fabr.) which was common in the laboratory grounds where the experiments took place, will rapidly remove dead mealy bugs from pineapple plants. Counts made immediately after the application of an insecticide in order to avoid this activity of ants would preclude the operation of any residual effect of the treatment.

In dipping tests, infested planting material was submerged for form three to five minutes in the insecticide and afterwards stacked butt up on the ground. In the spray tests the individual pieces of planting material were set upright in wide mouth jars and spray materials applied with a small hand pump.

In field experiments, hand sprayers were used for some time but it soon became evident that high pressure directed into the heart of the plant was necessary in order to obtain a satisfactory kill and at the same time avoid burning of the plant tissue. With the development of suitable pressure machinery by the pineapple companies, large scale experiments were set out along the edges of pineapple fields.

MATERIALS USED: For the most part easily available commercial insecticides were tried and are listed by name in the tables. "Johnsontine" is a proprietary compound, the property of one of the pineapple companies and the result of considerable experimentation on the part of Mr. M. O. Johnson. This material will be discussed further in connection with the economics of spraying, but at this point it can be

TABLE 1. COMPARISON OF MISCELLANEOUS INSECTICIDES APPLIED AS DIPS AND SPRAYS

Check Prior to Treatment	Aphex Emulsion 1–50		Rotenine 1–100	Rotenine 1–200	Petrotine 60 1–50		Johnsontine 1–50		Check After Treatment
	Dipped	Sprayed	Sprayed	Sprayed	Dipped	Sprayed	Dipped	Sprayed	
115	9	2	1	—	—	–	–	3	104
117	8	–	26	22	—	2	–	1	84
145	58	6	9	13	14	1	–	–	30
43	3	–	22	25	—	3	4	5	81
84	–	2	33	20	—	7	2	3	58
143	3	1	1	2	—	2	–	4	73
120	6	2	6	3	29	6	–	1	31
75	11	–	3	58	4	–	–	–	63
164	34	1	1	16	7	2	–	–	55
184	24	1	128	10	1	1	4	1	68
150	1	8	—	9	—	–	1	–	99
101	17	1	32	14	—	–	–	2	114
23	–	4	2	15	4	–	–	5	61
68	6	2	3	15	1	–	–	–	125
67	2	4	97	16	—	1	2	7	35

	Check Prior to Treatment	Aphex Emulsion 1–50		Rotenine 1–100	Rotenine 1–200	Petrotine 60 1–50		Johnsontine 1–50		Check After Treatment
		Dipped	Sprayed	Sprayed	Sprayed	Dipped	Sprayed	Dipped	Sprayed	
Per cent of plants infested....	100	87	80	93.4	93.4	46.6	60	33.4	66.6	100
Average population on infested plants.....	107	14	3	26	17	9	3	3	3	72

said that the material is a neutral oil with high unsulfonated residue and dispersed by mechanical means on an inert carrier.

TABLE 2. COMPARISON OF CERTAIN OIL EMULSIONS APPLIED AS DIPS

Check Prior to Dipping	Pineapple Spray No. 1 2%	Pineapple Spray No. 3[1] 2%	S. W. Free Mulsion 2%	S. W. Summer Mulsion 2%	Check After Dipping
267	17	40	76	45	202
514	1	1	93	147	468
686	8	6	69	54	388
645	1	5	58	72	305
630	1	–	16	13	520
530	3	11	212	56	239
350	97	2	1*	79	292
474	7	5	138	177	540
478	11	1	55*	179	307
679	1	–	31*	152	448
278	30	8	3*	71	228
358	15	2	1*	50	379
420	118	1	46*	114	210
503	11	8	31	36	283
688	10	–	35	30	215
175	4	–	76	114	330
500	7	*	58	134	135
279	6	2	*	61	298
752	–	–	*	41	290
557	1	4	9	234	225
208	2	2	1*	123	245
591	24	8	*	83	136
314	–	3	18*	128	663
425	6	8	5*	131	580
704	2	–	1	173	310

	Check Prior to Dipping	Pineapple Spray No. 1 2%	Pineapple Spray No. 3[1] 2%	S. W. Free Mulsion 2%	S. W. Summer Mulsion 2%	Check After Dipping
Per cent of plants infested..	100	92	72	88	100	100
Average population on infested plants.....	480	17	7	47	100	329

*Heart leaves burned.

[1]Specifications of this oil are as follows:

1. Per cent distillate at 636°F. 100%; oil content 83%; water and emulsifier 17%.
2. 40° Baume.
3. Viscosity 45 saybldt illuminating.
4. Unsulphonatable residue 95%+. The distillation is as follows:
5. Initial boiling point 375°F.
   5% at 395, 10% at 405, 20% at 415, 30% at 422, 40% at 430, 50% at 437, 60% at 442, 70% at 450, 80% at 459, 90% at 471, 95% at 484.

DISCUSSION OF THE PRELIMINARY TRIALS: Table 1 shows comparative results obtained with four materials. The two mineral oil compounds were most effective and almost exactly comparable when sprayed. The difference between the two when used as dips is accounted for

by the fact that Johnsontine breaks rapidly on dilution and the plants when dipped pass through a surface film of oil.

Table 2 compares four mineral oil emulsions, all Sherwin-Williams products. The results are interesting in indicating the relative value of various emulsion types, as well as variation in tendency to burn the foliage.

Experiments using Petrotine 60, both as dip and spray for planting material were repeated with essentially the same results, i. e., that 2% dilutions of this material were effective and safe. In addition, the price advantage of this material lead to its use in field experiments.

FIELD EXPERIMENTS: It was realized that field experiments would provide a much more severe test of insecticides than was possible in the laboratory. Populations might build up through reinfestation from outside sources; ants might remove the colonies below ground and out of reach of sprays, while regular spraying might result in oil injury to the plant. This last possibility lead to the inclusion of lower strength sprays as well as a combination of Petrotine 60 and Black Leaf 40.

Intervals between sprayings were placed arbitrarily at 2 weeks and one month, at the beginning of the experiments. These intervals were changed as experience was gained and it was found that the longer interval was sufficient.

SAMPLING METHODS: Detailed diagrams showing the type of plot are included in another paper (4). Mealy bug infestation occurs first on the outer edge of a field, coming in from old plantings or from wild vegetation, so most of these tests were arranged along the edge of fields so as to provide for as great a natural infestation as possible. The plots therefore were for the most part long and narrow. Experience proved that infestation, even within the limits of one plot, was extremely variable both as to size and time of initial infestation but the plots were of sufficient length and each treatment was replicated a number of times to ensure tests under several degrees of infestation.

Tables three to six inclusive are for the most part summaries of samples taken according to the methods described in the above-mentioned paper. With the growth of plants and the necessity for including a great many more plants in the sample than was possible with the method of pulling plants and counting the individual insects thereon, another method was used during July. In the case of these samples, a large number of plants were examined without pulling up the plants. The leaves were carefully separated and any mealy bug infestation noted. In Tables 3 and 4 therefore, under date of July 15th, the percentage of infestation only is given, there being no count of the actual

a

b

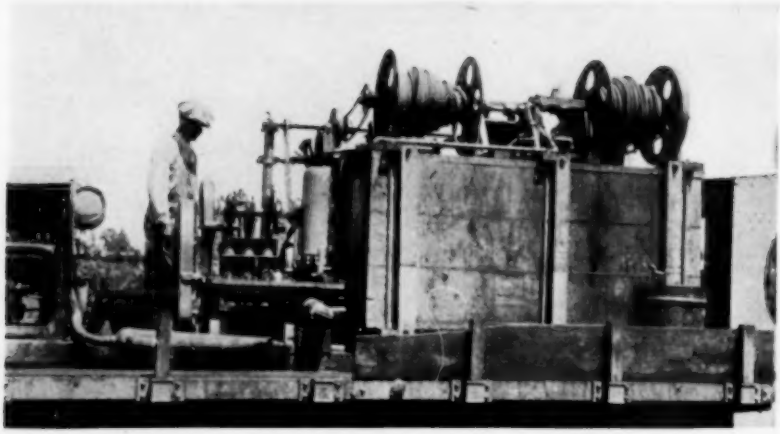
c

a. Spraying pineapples with ten-nozzle machine. Five nozzles to each hose. b. Showing handling of hose at end of line. c. Four-nozzle spraying. The picture shows workers on return trip towards machine. Note spray being directed into hearts of plants.

a

b

c



a. Arrangement of drums on side of machine with flexible pulley arrangement to take care of hose winding. Two men to each hose. b. Showing hook-up of nozzles with main hose and sling attachment over worker's shoulder. c. Spray tank, pump and drums for winding up and paying out hose line.

number of mealy bugs present. Any plant showing a single mealy bug, however, was included in the infested total. This method tends to accentuate infestation in the plots as compared with the checks, since populations in the checks were uniformly high on individual plants while the populations on the plants considered as infested, in the spray plots, were extremely low.

METHOD OF APPLICATION: Preliminary tests soon showed the necessity for what amounts to individual treatment for each plant. With hand sprayers, which were first used, this proved expensive in labor and unless carefully supervised, was ineffective. There was also some oil injury due to lack of agitation.

As soon as pressure machinery was available, the insecticides were applied at a pressure of approximately 200 lbs. at the nozzles, using machines especially designed for spraying of pineapple plants by the engineering staffs of the companies.

The only essential difference between these machines and standard high pressure orchard sprayers is in the device for handling hose. Pineapple fields are planted in blocks approximately 300 feet in width so that in order to reach the entire width from the plantation road, 150 foot hose lengths are used. Two of these are used on each machine and are wound on drums. The number of nozzles varies in the different companies and also with the type of power plant used. As many as five nozzles are used for each hose and as few as two, so that in addition to the men handling the truck and pump, as many as ten men may be employed at the nozzles, together with one or two men employed for hauling out hose and keeping the hose from dragging plants. The usual procedure is for the gang to proceed down the bed of plants, spraying one side of the bed going out, and the nearest side of the adjoining bed on the return trip. Most of the machines are devised so that the hose is reeled back automatically on the return trip. The cost of spraying per acre is approximately the same for the ten nozzle machine as for the four.

It has been found that a heavy stream directed into the heart of the plant is necessary to obtain control. The insects are almost invariably localized on the inner leaves and near the tender heart tissue so that high pressure, while useful in wetting mealy bugs which may be higher up on the leaves, is essential in quickly filling the heart of the plant and driving the material between the closely appressed inner leaves.

The volume of material used varies greatly with size of plant and type of planting but between 400 and 500 gallons of spray per acre is probably an average amount on young plants.

TABLE 3. PETROTINE 60, 2% APPLIED FORTNIGHTLY AND MONTHLY FROM NOVEMBER 23, 1930 TO FEBRUARY 26, 1931

All plots sprayed May 25, 1931 and June 23, 1931
(Odd numbers—fortnightly; Even numbers—monthly)

Sampling Dates	Plot 1		Check A		Plot 2		Check B		Plot 3		Check C		Plot 4		Check D	
	%[1]	Av.[2]	%	Av.	%	Av.	%	Av.	%	Av.	%	Av.	%	Av.	%	Av.
11/30/30	16	6	42	7	29	5	36	3	89	15	100	7	27	3	13	59
1/ 6/31	5	8	47	21	7	1	28	17	5	1	100	16	13	1	25	16
3/16/31	0	0	12	54	0	0	21	31	0	0	100	89	0	0	37	26
7/15/31	0	–	4	–	3	–	19	—	4	—	100	—	11	–	66	—

[1]Per cent of plants infested.
[2]Average population on infested plants.

TABLE 4. PETROTINE 60, 1% APPLIED EVERY TWO WEEKS FROM NOVEMBER 23, 1930 UNTIL JANUARY 26, 1931 AND MONTHLY THEREAFTER

Sampling Dates	Plot 1		Check A		Plot 2		Check B		Plot 3		Check C	
	%[1]	Av.[2]	%	Av.	%	Av.	%	Av.	%	Av.	%	Av.
11/12/30.....	90	24	92	29	94	18	100	97	69	102	88	64
1/ 7/31.....	44	6	95	31	14	2	100	83	50	43	88	30
3/ 9/31.....	0	0	59	36	0	0	78	17	36	43	21	162
7/15/31.....	16	—	84	—	5	—	71	—	0.5	—	84	—

[1]Per cent of plants infested.
[2]Average population on infested plants.

TABLE 5. PETROTINE 60, 1%+½ BLACK LEAF 40 APPLIED TO 100 GALLONS MONTHLY AND FORTNIGHTLY FROM NOVEMBER 10, 1930 TO FEBRUARY 26, 1931

Sampling Dates	Plot 1		Check A		Plot 2		Check B	
	%[1]	Av.[2]	%	Av.	%	Av.	%	Av.
12/ 5/30	40	2	81	13	73	6	75	10
3/23/31	0	0	71	46	11	3	36	24

Sampling Dates	Plot 3		Check C		Plot 4		Check D		Plot 5	
	%[1]	Av.[2]	%	Av.	%	Av.	%	Av.	%	Av.
12/ 5/30.....	75	2	63	6	53	7	33	4	53	2
3/23/31.....	0	0	68	24	0	0	5	3	0	0

[1]Per cent of plants infested.
[2]Average population on infested plants.

TABLE 6. 1.2% TOBACCO DUST APPLIED MONTHLY FROM FEBRUARY TO JUNE 1931

Sampling Dates	Plot 1		Check A		Plot 2		Check B	
	%[1]	Av.[2]	%	Av.	%	Av.	%	Av.
2/ 2/31.....	53	14	55	16	10	8	15	8
5/11/31.....	50	58	60	22	6	3	25	4

[1]Per cent of plants infested.
[2]Average population on infested plants.

DISCUSSION OF TABLES 3 TO 6, SHOWING DATA FROM FIELD EXPERIMENTS: The results shown in Tables 3 and 4 indicate that under both these conditions of application and percentage strength of spray, effective control was obtained. In the case of Table 5, showing data on the experiment where Black Leaf 40 was included in a Petrotine spray, the results are also encouraging, but not of a sufficient degree to

justify the inclusion of the Black Leaf 40 in the oil spray. Table 6, which shows data on a tobacco dust experiment is not encouraging since practically no change was noted either in percentage of infestation or average number of mealy bugs per infested plant. The application of tobacco dust to pineapple plants is expensive both in material and labor since hand application of the dust to the heart of the plant is necessary. It would appear, therefore, that the application of 1.2% tobacco dust to mealy bug control is not effective and cannot be compared with oil emulsions in effectiveness. Experiments on the use of higher percentage tobacco dust are now under way and will be reported on their conclusion.

HOME-MADE EMULSIONS: As mentioned in Table 1 "Johnsontine" showed results comparable to those obtained with Petrotine 60. This has also been true in field experiments and the results are a matter of interest in connection with the economics of spraying as well as with the subject of tank mixing. "Johnsontine" holds up well under stock solution. When diluted, it separates rapidly and requires extreme care in handling in order to avoid oil injury to the plant.

The anatomy of the pineapple plant is such that after spray has been applied, the heart of the plant is filled with spray solution. When the emulsion "breaks" the oil concentrates on the surface of the solution and burning occurs on the tender inner whorl of leaves. Two per cent Petrotine sprays represent the maximum strength that could be used safely, while with "Johnsontine," 1/65 has proved to be safe. The difference between these two materials with respect to safety indicates that the quicker the "break" occurs the more danger there is from burning.

The fact that these mechanically dispersed oils are being successfully used, however, is significant from the standpoint of the economics of spraying since they can be made for approximately two-thirds of the present cost of commercial emulsions. Their only disadvantage lies in the fact that they are not as safe as the commercial emulsions and with the type of labor available, this is an important consideration.

SUMMARY: Experiments on the control of *Pseudococcus brevipes* Ckl., the pineapple mealy bug in the Hawaiian Islands indicates that the use of oil emulsions provides a satisfactory method of control. New spraying devices have been made by the pineapple companies in order to cope with the necessity of a fine spraying material direct to the heart of each individual plant. The use of tobacco dust as a control measure against *Pseudococcus brevipes* Ckl., has not been successful. The susceptibility to burning on the part of the pineapple plant imposes severe restrictions

on the use of oil emulsions as well as mixtures of the tank-mix type. With adequate supervision, however, mixtures of the latter type can be successfully used.

Explorations for suitable parasites of *Pseudococcus brevipes* Ckl., are being conducted in cooperation with the Territorial Board of Forestry and Agriculture but the use of oil emulsions is recommended as an immediately available control. The effect of eliminating mealy bugs from pineapple plants on the incidence and extent of edge wilt of pineapples occurring in first ratoon await the completion of long term experiments set out for the purpose of obtaining such data.

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SOME OBSERVATIONS ON ELECTRIFIED SCREENS AND TRAPS

By R. W. Wells, *Associate Entomologist, Bureau of Entomology, U. S. Department of Agriculture*[1]

Abstract

In this paper are given the results of some tests with electrified screens and traps as compared with the much used trap of the cylinder type. The respective catches are analyzed by species and percentages are given. Also are recorded observations on rather complete installations of electrified screens on farm buildings and general observations from intimate experience with their use experimentally.

The determination of the practicability of electrified screens and traps for controlling house flies, stable flies, and various blowflies has become an urgent question recently because of numerous inquiries from correspondents in several states. Mehrhof and Van Leeuwen[2] in their experiments with an electrified trap on the Japanese beetle con-

[1]Contribution of the Division of Insects Affecting Man and Animals, F. C. Bishopp, In Charge.

[2]Mehrhof, F. E., and Van Leeuwen, E. R. An Electrical Trap for Killing Japanese Beetle. Jour. Econ. Ent. 23: 275–278. Illustr. 1930.

cluded that it could be used to advantage in certain locations. Electrified screens have been developed for windows and doors of buildings, and during the summer of 1930 the author had the opportunity to inspect several such installations.

During the month of September 1930, some tests were made at Bethesda, Maryland, to study the operation of electrified screens under different conditions. Tests were also made to compare the efficacy of electrified traps with that of the much used traps of the cylinder type as described by Bishopp.[3]

The electrified screens and the transformers used were those as were available from an established manufacturer. The source of current was from the standard household line of 110 volts, 60 cycle, alternating. By means of the transformer the current is stepped up by induction to approximately 3,500 volts. The wires of the screen are arranged parallel, with positive and negative wires alternating so that when an insect with its moist body comes in contact with the wires of the screen, the gap is thus shortened and the current flashes through the insect. The spark is similar to that produced by a spark plug of an automobile.

To get the utmost efficiency from an electrified trap and to compare its efficiency with that of a cylinder trap, it was decided that the electric trap should have a vertical aspect and should be quadrangular, or four-sided, so that flies approaching from any direction would have greater opportunity to come in contact with the wires. A four-sided electric trap (Plate 53, Fig. 1) was designed, each side fitted with an electrified screen 16 by 24 inches. Over the top of the trap was mounted a roof of pyramid shape with extending eaves to protect the electrified screens from rain. The transformer was mounted under the roof.

The trap, with roof, was mounted in the center of a platform 4 feet square, approximately 4 feet from the ground. The wide platform with side boards at the edges made it possible to collect the electrocuted flies falling from the wires of the screens. This four-sided trap was the one used in experiments Nos. 1, 2, and 3. In experiments Nos. 4 and 5, an electric box trap was used. This was made by using only one of the electrified screens, 16 by 24 inches, horizontally placed, fitting flush into the top of a box of the same lateral dimensions, and 6 inches deep. The bait pan in this instance was placed on the floor of the box with a fly screen over the pan to prevent the electrocuted flies from falling into the bait. This box trap was used on the same platform as the one previously used for the vertical trap.

[3]Bishopp, F. C. U. S. Dept. of Agr. Farmers' Bul. No. 734. June 10, 1916.

TABLE 1. COMPARISON OF FLIES DESTROYED IN VERTICAL ELECTRIC AND CYLINDER TRAPS

Exp. No.	Bait Used	Dates of Test	Number of Days	Number of Flies Caught: Electric Vertical Trap	Number of Flies Caught: Cylinder Trap	Percentage of Species: M. domestica *Per cent*	Phormia spp. *Per cent*	Lucilia spp. *Per cent*	C. macellaria *Per cent*	Undeterminable *Per cent*
1	Molasses and Bananas	Sept. 8–10	2	19,702	———	95.5	1	0.5	—	3
					13,658	94.5	–	2.5	—	3
2	Molasses and Bananas	Sept. 10–13	3	25,531	———	97	–	–	—	3
					20,366	92	2	6	—	—

TABLE 2. COMPARISON OF FLIES DESTROYED IN VERTICAL AND HORIZONTAL ELECTRIC TRAPS, CYLINDER TRAP, AND ELECTRIC SCREEN IN WINDOW

Exp. No.	Bait Used	Dates of Period	Number of Days	Number of Flies Caught: Electric Trap	Number of Flies Caught: Cylinder Trap	Number of Flies Caught: Electric Screen in Window	Percentage of Species: Musca domestica *Per cent*	Phormia spp. *Per cent*	Lucilia spp. *Per cent*	C. macellaria *Per cent*	Calliphora spp. *Per cent*	Undeterminable *Per cent*
3	1 lb. beef liver and water	Sept. 15–19	4	*vertical trap* 28,897			85	9	5	–	1	–
					31,477		54	40	5	1	–	–
						36,670	83	10	6	–	–	1
4	1 lb. beef liver and water[1]	Sept. 22–26	4	*flat box* 55,048			64	16	20	–	–	–
					51,569		60	21	19	–	–	–
						37,058	95	—	5	–	–	–
5	1 lb. beef liver and water[1]	Sept. 27 to Oct. 1	4	*flat box* 10,564			86	8	4	–	2	–
					23,279		71	15	13	1	–	–
						46,444	99	—	1	–	–	–

[1]No bait used in electric window screen.

Ten feet distant from this electric trap was mounted a cylinder trap on a platform approximately 3 feet high. This trap was 18 inches in diameter and 24 inches high. In each experiment the cylinder trap was baited exactly as the electric trap used. The electric window screen (mentioned later), however, was operated concurrently in experiments 4 and 5 without any bait except the odor from the dead and burning flies.

The location selected for the cylinder and electric traps was on the south side of a horse stable, under the shade of trees.

To observe the operation of an electrified screen as in the window of a building, a screen 26 inches wide by 36 inches high was installed on the south side of a small building (Plate 53, Fig. 1). The size of the room which the window served was 3½ by 4 feet. This building stood in direct sunlight about 30 yards from the location of the cylinder and electric traps. In experiments Nos. 4 and 5 the operation of this screen was begun and stopped concurrently with the cylinder and electric traps to compare the results. The dead flies were caught in a receptacle built outside and below the window. Those falling inside were gathered up with a small broom.

Method of Computing the Number of Flies.—At the end of the period of each test the flies were killed by fumigation and placed on screen cloth trays to dry. Several days later the lots were weighed separately and the number of flies in 10-gram samples of each lot were counted. From these counts the number of flies of the entire lot was computed. The percentage of flies of the different species was estimated by determining 100 flies from each lot.

Baits Used.—Two types of baits were used: (1) black cane molasses, 1 part with 3 parts of water, together with 3 peeled bananas and skins; (2) one pound of beef liver with water added to keep it moist.

Experiments Nos. 1 and 2.—See Table No. 1. These tests were designed to get a preliminary comparison between the standard cylinder trap and the vertical electric trap, identically baited, similarly located, and operated concurrently. The weather during these two tests was dry and warm, with practically no breeze.

In both of these tests the vertical electric trap killed the larger number of flies. It is to be noted also that predatory insects carried away a few of the flies falling from the electric trap. Also, no doubt, a few of the disabled flies were able to crawl up the side boards and off from the platform.

Experiment No. 3.—Table No. 2. Here the liver bait was used and we find a larger number of blowflies, as expected. In this test, too, the

window screen was operated concurrently with an identical bait placed in the room about 2 feet from the screen. Here we find the cylinder trap with a larger catch than the vertical electric trap, and the electrified window screen with the largest catch, though with a lower percentage of blowflies.

EXPERIMENTS NOS. 4 AND 5.—Table No. 2. All during these tests the temperature was lower, with nights uncomfortably cold. The flat box type of electrified trap previously described was used beside the cylinder trap, each baited with 1 pound of beef liver. Concurrently with these, the window screen in the experimental house was operated without bait excepting the odor of dead and burning flies. Results in these two tests vary so considerably that they seem unsatisfactory. The variations may be due to meteorological factors. The nights were steadily becoming cooler. Probably the temperature had something to do with the number of flies killed by the window screen and the high percentage of house flies among them. The house flies obviously seek shelter in cool weather.

EFFECT OF RAIN ON ELECTRIFIED SCREENS.—The screens used had steel frames and porcelain insulators. During a shower when the screens became splashed with rain they were inoperative from the moisture and remained so for several hours after the end of the shower.

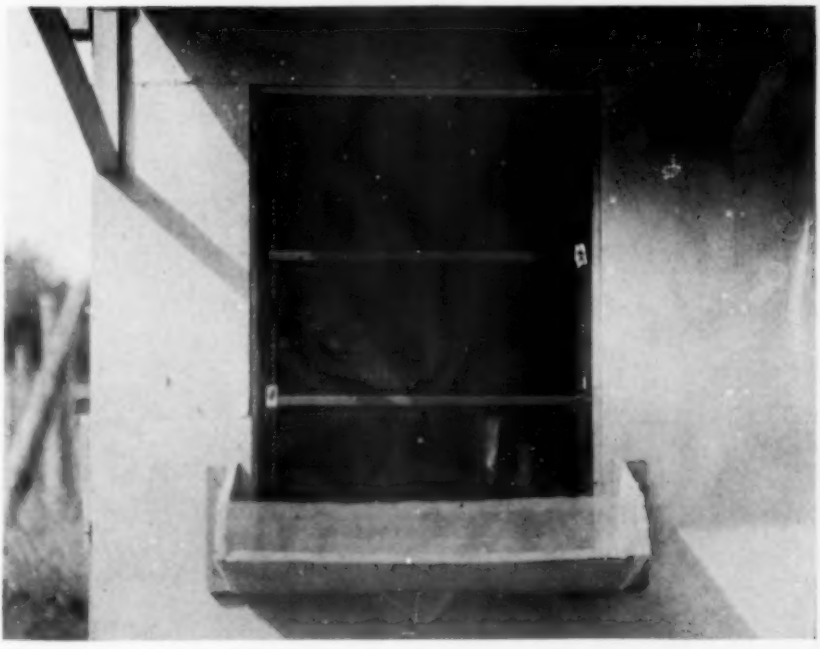
ODOR FROM BURNING FLIES.—Frequently, flies striking the screen adhere to the wires and the current literally cremates them. When flies are abundant, this cremation and the resulting odor are almost continuous.

LITTER FROM FALLING FLIES.—Approximately one-third of the flies falling from the electrified window screens fall through the screen to the inside of the room. A receptacle could no doubt be developed to catch many of them. Some of them, however, merely lose a leg or a wing, and can still crawl along. It appears to be a difficult matter to prevent such falling and crawling flies from littering the floor.

FLIES ESCAPING THE CURRENT.—Occasionally when flies were abundant, a few flies were seen to dart through the screen uninjured. This, however, is rare when the screens are dry and clean and the wires evenly spaced. Flies of the genus Drosophila are so small that they dart between the wires without being affected. The manufacturer of the screens used asserts that improvements are being made in the screens to make them impervious to the smaller insects.

ELECTRIFIED SCREENS IN DAIRIES, ETC.—On July 28th the writer visited a dairy farm located about 20 miles south of Chicago, Illinois, where there was rather an elaborate equipment of electrified screens.

Electric trap four-sided, vertical installation on platform.



Electrified screen as installed in experimental house.

The windows and doors of the dairy barn and the windows of a calf barn were equipped with the electrified screens. Flies were abundant and the day was hot. It was very impressive to note the number of dead flies at the bases of the electrified screens. Within the calf barn flies were exceedingly abundant around the walls and the ceiling. Most of these were house flies. Among the dead flies at the several windows of the two barns were found a few specimens of *Tabanus lineola* Fab. and one specimen of *Tabanus sulcifrons*. Macq. The latter was alive though apparently badly crippled by the electric screen. At the bases of the windows of the calf barn and the dairy barn a few ounces of the dead flies were gathered for examination. An average lot of 100 flies was taken from the collection and the findings are as follows: *Musca domestica* L., 69; *Stomoxys calcitrans* L., 28; *Lucilia* sp., 1; *Phormia* sp., 1; undeterminable, 1. We believe it is fair to assume that not more than 30 per cent of the flies were biters or blood-suckers.

CONCLUSIONS.—For destruction of house flies and blowflies, electrified traps show great possibilities. To the cylinder traps can be credited the advantage of requiring no shelter, being unaffected by rain, being located far from current and being easily moved.

In windows where litter from falling flies and the slight odor mentioned are no consideration, the electric screen is a good destroyer, even without bait.

Electric screens do not exclude flies from buildings while the screens are wet.

A few flies pass through the electrified screens, apparently uninjured.

SOME FACTORS AFFECTING THE COMPOSITION OF DRY LIME-SULFUR SOLUTIONS[1]

By D. E. BULLIS,[2] *Department of Agricultural Chemistry, Oregon Agricultural Experiment Station, Corvallis, Oregon*

ABSTRACT

A study of the factors affecting the composition of solutions made from dry lime-sulfur.

Since the advent on the market of dry lime-sulfur, much contradictory data have been presented concerning its effectiveness in the

[1]Published as Technical Paper No. 152 with the approval of the Director of the Oregon Agricultural Experiment Station.

[2]From a thesis submitted to the Graduate Committee of Oregon State College in partial fulfillment of the requirements for the Master of Science Degree.

control of scale insects. This is well summarized by Abbott and his associates.[3] Gray and Thompson[4] have noted that the composition of solutions prepared from dry lime-sulfur may vary widely, depending on the manner of preparing the solution, and it was thought that a study of some of the factors affecting the composition of such solutions might be of value in interpreting the results obtained in the field.

Dry lime-sulfur contains about 65% of calcium polysulfides, 8% of calcium thiosulfate and calcium sulfate, and variable amounts of stabilizer and moisture. The liquid lime-sulfur from which it is prepared contains approximately 30% calcium polysulfides, 2% calcium thiosulfate, traces of calcium sulfate, and the remainder is water. It has a specific gravity of 32° or 33° Baume (sp. gr. 1.283 to 1.295).

TABLE 1. EFFECT OF METHOD OF SOLUTION ON COMPOSITION OF SOLUTION OF DRY LIME-SULFUR

Method	Temp.	% Sludge	% Thiosulfate Sulfur	% Monosulfide Sulfur	% Sulfide Sulfur	Monosulfide: Sulfide Ratio
I	25° C.	8.98	4.74	12.06	51.12	1:4.23
II	25° C.	13.46	4.10	12.00	47.44	1:3.95
I	30° C.	7.35	5.38	12.07	52.44	1:4.35
II	30° C.	12.23	4.73	11.90	47.84	1:4.02

The evaluation of liquid or dry lime-sulfurs for scalicidal use is generally considered as best represented by the monosulfide: sulfide ratio which in reality is an expression of the atomic ratio of calcium to sulfur combined in the form of polysulfides. This is mentioned because the expression "monosulfide: sulfide" ratio is frequently used later in this paper and in the tables.

The points to be considered in this paper are the method of preparing the solution, which is primarily of interest to the analyst, and the effect of time, temperature, and concentration, which have a more practical application.

The manner of preparing the solution was first considered. In Method I, as used by Gray,[4] the sample is made to volume in a flask and shaken intermittently for a few hours, filtered, and the solution used for analysis. In the present work the flasks were immersed in a constant temperature bath controlled to ± .2° C. for 20 hours with occasional shaking. This method of solution allows the dissolved polysulfides to react for some time with the free sulfur of the sludge which, according

[3]Abbott, W. S., Culver, J. J. and Morgan, W. J. U. S. D. A. Dept. Bulletin 1371. 1926.

[4]Gray, Geo. P. and Thompson, Firman. State of Cal. Dept. of Agri. Special Pub. No. 58, pp. 29–31. 1925.

to Tartar,[5] produces a polysulfide of higher sulfur content; that is, more of the calcium pentasulfide. Method II, as used by the U. S. Food, Drug and Insecticide Administration, involves stirring the sample with small portions of water and decanting through a filter until the proper volume of solution is obtained. This method of solution prevents any prolonged action of the polysulfides on the free sulfur of the sludge and should yield a solution of less polysulfide content and one having a lower monosulfide: sulfide ratio. The analyses of solutions made by these two methods at 25° C. and at 30° C. are shown in Table 1.

As was anticipated, solution by Method I gave a higher polysulfide sulfur content, a smaller residue of sludge, and a higher ratio of sulfide to monosulfide sulfur. Although Method II probably gives a solution more nearly representative of the composition of the dry lime-sulfur, it is thought that the solution obtained by Method I approximates more nearly that produced in the spray tank and hence is of greater practical significance. Method I was used for preparing all solutions required in the remainder of this study.

TABLE 2. EFFECT OF TIME ON SOLUBILITY OF DRY LIME-SULFUR

Time	% Sludge	% Thiosulfate Sulfur	% Monosulfide Sulfur	% Sulfide Sulfur	Monosulfide: Sulfide Ratio
24 hours.....	14.34	2.51	11.68	44.88	1:3.84
48 hours.....	13.61	2.60	11.40*	45.36	1:3.98*
72 hours.....	12.41	2.78	11.76	45.88	1:3.90
96 hours....	11.56	3.01	11.76	46.40	1:3.95

*Aliquots for monosulfide sulfur determination taken after 24 hours under paraffin oil. This low value makes a correspondingly high value for the monosulfide: sulfide ratio.

The following experiment was designed to show the importance of time as a factor in the solubility of dry lime-sulfur.

Eight replicate samples of a commercial dry lime-sulfur were made to volume and the stoppered flasks immersed in a constant temperature bath at 20° C. ± .2° C. They were shaken intermittently during the day and at the end of each 24 hour period two flasks were removed from the bath, the solution filtered and aliquots taken from each duplicate solution for analysis. The results are given in Table 2.

Increase in time has brought about the solution of more sludge (which in this dilution is practically all sulfur) to give a solution containing more calcium thiosulfate and more calcium polysulfides having a higher proportion of sulfur to calcium. Since the monosulfide sulfur content is constant, which indicates no oxidation of the calcium poly-

[5]Tartar, H. Jour. Amer. Chem. Soc. *36:* 3. p. 498. 1914.

sulfides, there remain only two explanations for the increase in thiosulfates. Thiosulfates may be gradually dissolved from the sludge, which seems improbable in the dilutions used. The more plausible explanation is that a small amount of thiosulfate decomposes according to the reaction $CaS_2O_3 = CaSO_3 + S$. Although calcium sulfite is highly insoluble, enough could remain in solution at the dilution used so that if titrated with standard iodine and calculated as calcium thiosulfate, an apparent increase in thiosulfate would result. None of the solutions contained more than traces of sulfate sulfur.

TABLE 3. COMPOSITION OF SOLUTIONS OF DRY LIME-SULFUR OBTAINED AT DIFFERENT TEMPERATURES AS PER CENT OF DRY MATERIAL

Temp.	% Sludge	% Thiosulfate Sulfur	% Monosulfide Sulfur	% Sulfide Sulfur	Monosulfide: Sulfide Ratio
		Dry Lime-Sulfur A			
20°C.....	13.51	2.60	11.40*	45.36	1:3.98*
25°C.....	10.30	2.85	12.16	48.08	1:3.95
30°C.....	8.81	3.26	12.12	49.32	1:4.03
95°C.....	0.28	6.05	11.36	54.92	1:4.83
		Dry Lime-Sulfur B			
20°C.....	11.58	2.26	12.08*	49.16	1:4.07*
25°C.....	8.48	2.59	12.80	49.88	1:3.90
30°C.....	5.88	2.98	12.76	55.12	1:4.32
95°C.....	0.13	5.49	12.32	58.16	1:4.72

*Aliquots for monosulfide sulfur determination taken after 24 hours under paraffin oil. This low value makes a correspondingly high value for the monosulfide: sulfide ratio.

For the study of the effect of temperature on the solubility of dry lime-sulfur two commercial brands were used. Duplicate solutions of each were prepared as in the previous experiment. Immersion in the bath was for 48 hours at the temperatures of 20° C., 25° C., and 30° C. Similar duplicates were heated on the steam bath for two hours, the temperature being about 95° C. Longer heating resulted in partial decomposition with the formation of hydrogen sulfide and the separation of free sulfur. Analyses of the solutions are shown in Table 3.

While the effect of temperature is similar to the effect of time on the solution of dry lime-sulfur, the differences are much more pronounced. The sum of sludge, thiosulfate sulfur and sulfide sulfur is fairly constant for each brand regardless of the temperature. This indicates that as the sludge dissolves, a corresponding amount of polysulfide is formed. The increase in thiosulfate may again be accounted for as previously, although at the higher temperatures a portion of it is probably formed from the calcium polysulfides since the decreasing monosulfide sulfur values for these temperatures point toward a slight decomposition

of the polysulfides. It is also important to note that near the boiling temperature practically all sludge is dissolved and the monosulfide: sulfide ratio shows that the resulting solution has about the same proportion of tetrasulfide (CaS_4) and pentasulfide (CaS_5) as a good liquid lime-sulfur, although the content of calcium thiosulfate is considerably higher than contained in the latter.

To determine the relationship between concentration and the composition of dry lime-sulfur solutions, preparations were made containing 1, 2, 4 and 6 grams per 100 c.c. and shaken intermittently for three hours at room temperature. A fifth solution containing 6 grams per 100 c.c. was heated at 95° C. for 45 minutes. The existing relationships are shown in Table 4.

TABLE 4. EFFECT OF CONCENTRATION ON COMPOSITION OF SOLUTIONS OF DRY LIME-SULFUR A AS PER CENT OF DRY MATERIAL

Temp.	Grams per 100 cc	% Sludge	% Sludge Sulfur	% Thiosulfate Sulfur	% Monosulfide Sulfur	% Sulfide Sulfur	Monosulfide: Sulfide Ratio
Room	1	15.12	15.04	3.85	11.44	43.20	1:3.77
Room	2	15.90	14.30	3.65	11.20	44.70	1:3.99
Room	4	19.71	13.75	2.40	10.37	44.10	1:4.25
Room	6	23.75	14.15	2.54	9.70	42.80	1:4.42
95°C	6	0.18	0.07	5.12	12.18	53.97	1:4.42

In the higher concentrations at ordinary temperatures, it is obvious that a considerable amount of the insoluble material is not free sulfur. The sludge from the flask containing 6 grams of dry lime-sulfur per 100 c.c. retained some undissolved polysulfide as indicated by the color of the residue and of the solution which resulted from the treatment of the dried residue with water. The sludge from the more dilute preparations is nearly all sulfur. The percentage of dissolved calcium polysulfides is less in the more concentrated solutions, but the proportion of tetrasulfide and pentasulfide is higher than in the dilute solutions. Six or seven grams of dry lime-sulfur per 100 c.c. of water gives a solution comparable in concentration to that used as a dormant spray for scale insects. The above observations and the data from Table 4 lead to the inference that a considerable portion of the active ingredients of dry lime-sulfur remain undissolved when mixed in the spray tank. The application of such a suspension would not be as effective as the true solution of a like amount for the control of plant pests. It is quite evident that increase in temperature is of great importance in preparing the more concentrated solutions of dry lime-sulfur.

In summarizing the results of this work it may be said that the value of solutions of dry lime-sulfur for scalicidal purposes may be increased,

first, by allowing a longer time for solution to take place; second, and most important, by increasing the temperature of the water used to prepare the solution; and third and less important than temperature, by improving the monosulfide: sulfide ratio through increasing up to about 50 pounds the amount of dry material added to each 100 gallons of water. A combination of temperature increase and higher concentration of dry material produces a spray solution, the analysis of which approximates very closely that of a good quality liquid lime-sulfur, and it is believed that when used at equivalent strength should give as satisfactory control of scale insects.

SUGGESTIONS CONCERNING THE ANALYSIS OF POTASH FISH OIL SOAP USED FOR EMULSIFICATION

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ABSTRACT

A modified form of reporting analysis of fish oil soap to give the characters important in emulsification is suggested.

Potash fish-oil soap is an emulsifier widely used in the preparation of oil emulsions. Such soaps contain a mixture of saturated and unsaturated acids and free oils, and have varying alkali and water content. The usual method of analysis reports the percentage of fatty anhydride, K_2O, and water. From a standpoint of the effect of the soap on emulsions, the analysis in this form does not give all the desirable information. Numerous workers have shown the effect of the physical characteristics of the emulsion on the quantity of oil adhering following spraying. Several properties of the soap would be expected to influence these qualities. In the course of studies on oil emulsions at New Orleans, La., it became necessary to analyze soaps of this type to evaluate their effect on emulsion characteristics. In this paper a form of analysis modified to report the properties important in emulsification will be suggested.

The most important of these properties of course is the actual soap content, since that is the active emulsifying agent. But on the basis of the theory of molecular orientation at the oil-water interface it is the molar concentration of soap that is significant rather than the fatty anhydride by weight. For example, two lots of soap might show

the same percentage by weight, but if one contained a larger quantity of lighter acids, this would have more molecules of soap present to form the interfacial films. The soap content in terms of mols would show this condition, where the fatty anhydride by weight would give no indication.

In aqueous solution the soap will hydrolyze according to the following reaction

$$\text{K soap} + H_2O \rightleftharpoons KOH + \text{fatty acid}$$

An excess of alkali will tend to repress this hydrolysis, leaving more soap molecules available for emulsification. Harkins and Zollman(1) have found the addition of free alkali to yield an emulsion of smaller drop size, and to cause a remarkable decrease in surface tension of soap solutions. Hence the total alkali expressed as mols per gram is another essential point to be determined.

The mean molecular weight gives an index to the length of the hydrocarbon chain. The soaps of the various fatty acids differ in their emulsifying efficiency (2) and so in any work on emulsions it becomes important to have as much information as possible on this point.

Different sources of fish oil yield variations in the degree of unsaturation as well as length of the hydrocarbon chain. Since the unsaturated acids are generally more soluble than corresponding saturated compounds, it is usually possible to secure a higher concentration of emulsifier with such acids. The unsaturated compounds are also more effective in lowering the interfacial tension (3), and therefore we would expect them to be more efficient emulsifiers. This conclusion has been experimentally verified. Consequently the iodine number should be included in an analysis to indicate the degree of unsaturation.

The following will illustrate the type of analysis used at this laboratory. The standard A. C. S. methods (4) have been used, adding only the determination of the iodine number to the customary analytical methods. The samples were drawn from a barrel of commercial potash fish-oil soap which had been on hand for several years. About three pints were drawn into a mason fruit jar and sealed with airtight cover. All material for analysis was taken from this jar after thorough agitation. The value given in each case represents a mean of at least four determinations.

Soap content	— 0.000841 mols/gram
Total potassium	— 0.000970 mols/gram
Excess potassium	— 0.000129 mols/gram

This potassium was present as hydroxide and carbonate, but is not reported separately since in aqueous solution the carbonate will be

hydrolyzed. Furthermore, variations within wide limits of the carbonate-hydroxide ratio do not affect the pH within limits important for emulsifying properties, when the total alkali is held constant. Dilutions .029 N with respect to potassium agreed within 0.1 pH whether the potassium was added in the form of hydroxide or carbonate or as a mixture of the two. Attempts to determine the total alkali by titrating the aqueous solution of the soap with HCl gave uniformly low results. Electrometric titration with the antimony electrode was also tried but proved unsuccessful.

The mean molecular weight can be calculated from the weight of active soap and the molality. The sample in question showed

$$\frac{\text{gram active soap per gram of K. F. O. soap}}{\text{Mols/gram active soap}} = \frac{.2773}{.000841} = 330$$

$$\text{M. M. w. fatty acid} = 330 - 39(\text{K}) + 1\ (\text{H}) = 292$$

In determining the degree of unsaturation use was made of the absorption of iodine monobromide at a double bond according to Hanus method (5).

$$\text{I—Br} + \text{—C=C—} = \text{—C(I)—C(Br)—}$$

The iodine number expresses the number of centigrams of iodine absorbed per gram of soap, this sample giving an iodine number of 142. The mean number of double bonds per molecule of fatty acid can then be calculated by multiplying by the ratio $\frac{\text{mol. wt. soap}}{\text{I} \times 100} = 142 \times \frac{330}{126.9 \times 100} = 3.69$ double bonds per molecule of acid.

Summary

Qualities of potassium fish-oil soap which are most important from the standpoint of its efficiency in emulsifying oil and water are, molar concentration of soap and total alkali, mean molecular weight, and degree of unsaturation.

An analysis of one lot of soap showed.

Total soap — 0.000841 mols/gram K. F. O. soap.
Total potassium — 0.000970 mols/gram K. F. O. soap.
Total soap by weight — .2773 g/g K. F. O. soap.
Mean molecular weight of acid — 292
Mean double bonds per molecule — 3.69.

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USE OF WETTING OR DEGUMMING AGENTS IN THE REMOVAL OF SPRAY RESIDUES FROM APPLES[1]

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ABSTRACT

As a result of numerous experiments conducted at the New Jersey Agricultural Experiment Station, a new method of removing spray residues from fruit has been developed. By the addition of a textile wetting or degumming agent to a hydrochloric acid cleaning solution, it was found possible to economically and satisfactorily remove arsenical residues from New Jersey apples receiving 6 to 8 heavy applications of lead arsenate in cover sprays of which 1 to 4 contained oil emulsion. A heated cleaning solution was necessary only in one instance. Rapid and effective contact is established between the acid and lead arsenate by the use of wetting or degumming agents.

In sections of the United States, where heavy and late spray schedules have been imperative in combating insect infestation, the adoption of chemical cleaning methods for removal of spray residues at harvest has become general. In accordance with domestic and export market requirements, arsenical residues have been reduced below .012 or .01 grains As_2O_3 per pound of fruit, respectively, with a .5 to 1 per cent solution of hydrochloric acid, where calcium caseinate sticker and spreader has been applied in conjunction with lead arsenate sprays. Experiments in certain fruit growing districts of the United States indicate that insect control may be accomplished more effectively with a mixture of refined mineral oil emulsion and lead arsenate than with the lead arsenate calcium caseinate mixture. Fruit growers have, however, refrained from applying oil sprays because of greater difficulty experienced in removal of spray residues and the additional cost which is

[1]Journal series paper of the New Jersey Agricultural Experiment Station, Department of Spray Residue Investigations.

involved. Unfortunately, the use of oil sprays causes the formation of a resistant covering, which apparently prevents the ready interaction of the acid and lead arsenate during the cleaning process and thus reduces the effectiveness of the acid solution.

Several methods of washing oil sprayed and waxy fruit have been suggested in the northwest.

Diehl (1) et al have found heated combinations of hydrochloric acid and deodorized kerosene emulsion, also hydrochloric acid and sodium chloride more effective than hydrochloric acid alone in removing arsenical residues. Neller (2) reports that oil sprayed and waxy fruit previously dipped in methanol to remove coatings of oil or wax may be successfully cleaned in hydrochloric acid, whereas, washing with hydrochloric acid without the methanol treatment failed to remove such residues.

Our investigations have demonstrated that a heated or unheated mixture of salt and hydrochloric acid, or a heated or unheated mixture of deodorized kerosene and acid, is unable to remove arsenical residue in many instances sufficiently from New Jersey mineral oil and lead arsenate sprayed apples to meet export or domestic market requirements. Likewise, the methanol pre-dip method of Neller, (2) though proving superior as a solvent, offers serious difficulties. The necessity of conducting two separate washing operations, the greatly increased cost of processing resulting from the maintenance of additional washing equipment, the inflammability of methanol, and possible ill effects upon workers caused by prolonged exposure tend to minimize the value of the treatment.

In addition to numerous experiments with recommended fruit cleaning materials, certain recognized solvents of waxes and oils, as well as several materials employed in the textile industry as degumming or wetting agents were investigated.

Object of the Experiments. The object of our experiments was to find a suitable comparatively inexpensive substance for admixture with hydrochloric acid solution capable of removing arsenical residues from lead arsenate and oil sprayed fruit which would possess the following attributes: (1) Non-inflammable in nature, (2) affecting in no way keeping quality or appearance of the fruit, (3) a sufficiently effective solvent in itself without application of heat, (4) endangering the health of workers in no manner, and (5) suitable for use with homemade flotation washers or dipping tanks as well as different types of commercial washers in which the contact period with the acid is considerably shortened.

Wide Range of Materials Tested. Among the materials tested were methanol, acetone, dioxan, Ethylene glyco mono-butyl ether,

Ethylene glyco mono-methyl ether, pine oil soaps, pine oils, isopropyl alcohol, several sulfonated oils, several mineral oil emulsions, fusel oil, secondary butyl alcohol, and preparations employed in wetting or degumming silk capable of being used in acid solutions.

TABLE 1. A COMPARISON OF THE EFFICIENCY OF VARIOUS SOLVENTS ON RESIDUE REMOVAL

Cleaning Treatment	Time of Contact[4] with Cleaning Solution *Minutes*	Grains of As_2O_3 per pound of Fruit After Washing 71°F.[5]	100°F.[5]
Grimes Apples			
Checks untreated	–	.15	
2% HCl	1	.029	
2% HCl	2	.019	
2% HCl	3	.016	.012
2% HCl, 2% NaCl	3	.013	.009
2% HCl, .5% "Alkanol B"[1]	1	.017	
2% HCl, .5% "Alkanol B"	2	.013	
2% HCl, .5% "Alkanol B"	3	.011	.008
2% HCl, 2% NaCl, .5% "Alkanol B"	3	.008	.006
2% HCl, .5% "Neopen SS"[2]	1	.016	
2% HCl, .5% "Neopen SS"	2	.012	
2% HCl, .5% "Neopen SS"	3	.009	.006
2% HCl, 2% NaCl, .5% "Neopen SS"	3	.007	.004
2% HCl, 1% "Vatsol"[3]	1	.014	
2% HCl, 1% "Vatsol"	2	.008	
2% HCl, 1% "Vatsol"	3	.005	.002
2% HCl, 2% NaCl, 1% "Vatsol"	3	.004	.001
2% HCl, 1.5% Kerosene Emulsion	3	.030	.013
Wealthy Apples			
Checks—untreated	–	.17	
2% HCl	3	.024	.014
2% HCl, .5% "Alkanol B"	3	.014	.006

[1]A wetting agent of the alkylated naphthalene sulfonic acid type in the form of the white finely powdered sodium salt.

[2]A wetting agent which is a sulfonated abietene in the form of a light cream colored powdered sodium salt.

[3]A degumming soap in the form of a thick paste.

[4]The apples were gently agitated in the cleaning solution.

[5]Temperature of cleaning solutions.

Certain materials were satisfactory from the cleaning standpoint but were impracticable due to excessive cost, objectionable odors or injury to the fruit. Of the textile wetting and degumming agents "Alkanol B," "Neopen SS" and "Vatsol" proved most promising. The results obtained with these materials are reported in this paper.

RESULTS OF LABORATORY EXPERIMENTS. A comparison of the efficiency of the various treatments may be obtained from Table 1. The analyses reported are the results of recent laboratory experiments representing the average of 6–8 separate tests. Both varieties of apples included received 3 oil and lead arsenate (3 lbs. per 100 gal.) cover sprays

during June. In addition, the Grimes apples received 5 cover sprays of lead arsenate (4 lbs. per 100 gal.) with calcium caseinate as a spreader and sticker. The Wealthy apples also had 3 additional sprays of the same kind. Wealthies being harvested somewhat earlier than Grimes were exposed to effects of weathering for a shorter period, which may account for the difficulty experienced in cleaning this variety.

Three minute contact of the fruit with the cleaning solution, in laboratory tests conducted at the New Jersey Agricultural Experiment Station, gave the same cleaning effect as obtained with commercial washers. Attempts to remove arsenical residues with hydrochloric acid concentrations below 2 per cent[2] in various cleaning mixtures were unsuccessful. A solution containing 2 per cent salt and 2 per cent hydrochloric acid with 3 minute contact at a temperature of 71°F. failed equally to reduce residues significantly on Grimes apples. The addition of "Alkanol B," "Neopen SS," or "Vatsol" to the 2 per cent hydrochloric acid solution, however, effected a considerable reduction of the arsenical residue content with 3 minutes contact. Heating the solution to 100°F. further lowered the residues. The use of acid and deodorized kerosene at 71°F. with 3 minutes contact reduced the residues on Grimes to but .03 gr. As_2O_3 per pound of fruit, which is less efficient than 2 per cent hydrochloric acid alone. On heating the solution to 100°F., analyses revealed the presence of .013 gr. As_2O_3, an amount still in excess of market requirements. On the other hand, by the addition of any one of the wetting or degumming agents to either a 2 per cent hydrochloric acid solution or a 2 per cent hydrochloric acid and 2 per cent salt solution, the arsenical residues could be removed sufficiently. Only in one instance was it found necessary to heat the cleaning solution; a heated solution of the acid and "Alkanol B" being required in order to lower the arsenical load of the Wealthy variety below .01 gr. per pound of fruit. This variety was harvested before the other wetting agent and degumming soap were available for comparative tests.

The addition of a kerosene emulsion to the cleaning solution necessitates continuous agitation of the liquid in order to prevent separation of the oil from the cleaning mixture. The successful use of this material is, therefore, restricted to commercial types of washers. On the other hand, the wetting agents and degumming soaps are completely miscible in dilute hydrochloric acid solutions and may be used satisfactorily in all types of washers.

In the course of our investigation, it was also shown that the "Alkanol

[2]All percentages given in this paper are on weight basis.

B" is an excellent spreader for oil. Limited laboratory experiments indicate that if it were possible to use this material as a spreader in the lead arsenate oil emulsion spray mixture, the subsequent removal of residues with the dilute hydrochloric acid solution would be greatly facilitated.

TABLE 2. INFLUENCE OF WETTING AGENTS ON THE EFFICIENCY OF CLEANING SOLUTIONS IN VARIOUS TYPES OF FRUIT WASHERS

Cleaning Treatment	Variety of Apple and Number of Oil Sprays[1]	Type of Washer Used: Flotation	Spray	Flood
		Grains of As_2O_3 per pound of Fruit After Washing		
	Jonathan			
2% HCl	(one)	.015	.012	.012
2% HCl, .5% "Alkanol B"	(one)	.008	.006	.008
	Winter Banana			
2% HCl	(four)	.011	.02	.016
2% HCl, .5% "Alkanol B"	(four)	.006	.011	.010
	Winter Banana			
1% HCl	(three)	—	.025	—
2% HCl	(three)	.014	.015	.016
1% HCl, .5% "Alkanol B"	(three)	—	.02	—
2% HCl, .5% "Alkanol B"	(three)	.01	.009	.010
	Winter Banana			
2% HCl	(no oil spray)	—	.004	—
2% HCl, .5% "Alkanol B"	(no oil spray)	—	trace	—
	Winter Banana			
1% HCl, 1.5% Kerosene Emulsion	(three)	—	.063	—
1% HCl, 1.5% Kerosene Emulsion (heated to 100°F.)	(three)	—	.030	—
2% HCl, 1.5% Kerosene Emulsion	(three)	—	.052	—
2% HCl, 1.5% Kerosene Emulsion (heated to 100°F.)	(three)	—	.015	—
	Grimes			
1% HCl, 1.5% Kerosene Emulsion	(three)	—	.045	—
1% HCl, 1.5% Kerosene Emulsion (heated to 100°F.)	(three)	—	.016	—
2% HCl, 1.5% Kerosene Emulsion	(three)	—	.030	—
2% HCl, 1.5% Kerosene Emulsion (heated to 100°F.)	(three)	—	.013	—
2% HCl	(three)	.013	.015	—
2% HCl, .5% "Alkanol B"	(three)	.009	.010	—
	Smokehouse			
2% HCl	(four)	.017	.020	—
2% HCl, .5% "Alkanol B"	(four)	.007	.009	—
	Wealthy			
2% HCl	(three)	.026	.029	.027
2% HCl, .5% "Alkanol B"	(three)	.015	.016	.013

[1]The Wealthy variety received a total of 6 lead arsenate cover sprays, all other varieties received 8 cover sprays.

PRACTICAL TESTS UNDER PACKING HOUSE CONDITIONS. The effectiveness of the wetting agents and degumming soap used with hydrochloric acid under actual packing house conditions is indicated by the

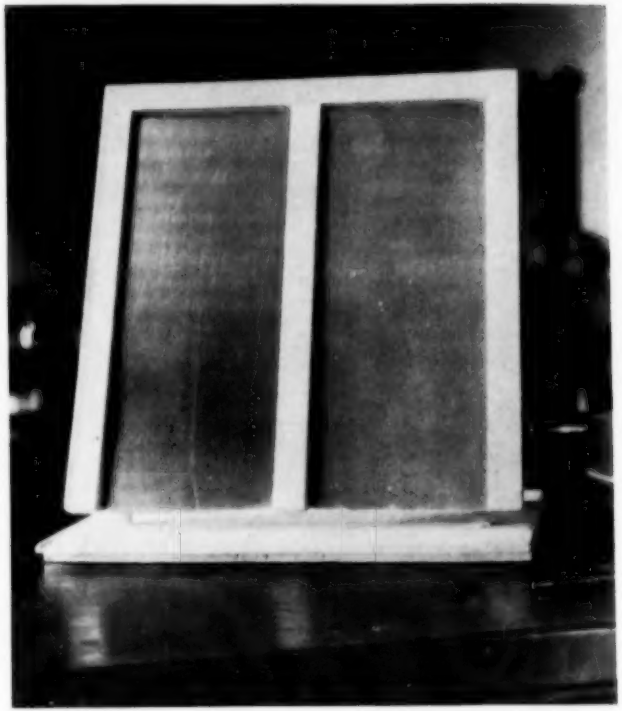
results secured with "Alkanol B" for three types of fruit washers. (Table 2). Unless otherwise noted, the temperature of the cleaning solutions was maintained at 70°F. The Grimes and Wealthy apples used in these experiments received the same sprays as those shown in Table 1. The other varieties included received oil and lead arsenate sprays during the latter part of July and in August, having been previously sprayed heavily with lead arsenate and calcium caseinate. In the spray and flood type washers, the fruit was in contact with the acid cleaning solution for 28 seconds, except where kerosene was used, in which case the contact period was 42 seconds. With the homemade flotation washer the contact period averaged 3 minutes.

Prevention of Foaming in Commercial Washers. The use of the wetting and degumming agents in admixture with dilute hydrochloric acid caused considerable foaming in the flood and spray type commercial washer, and necessitated the addition of an anti-foam agent. The search for a material which would not affect the efficiency of the cleaning solution, or injure the fruit, and have no objectionable odor culminated in "Bellone," a commercial material which is a mixture of alcohols and ketones containing 6–10 carbon atoms. A solution concentration of .1 per cent to .2 per cent was necessary to prevent foaming. Pine oil and fusel oil, though equally effective in preventing foaming, were discarded because of some objectionable features. The antifoam mixture was not required with the homemade flotation machine.

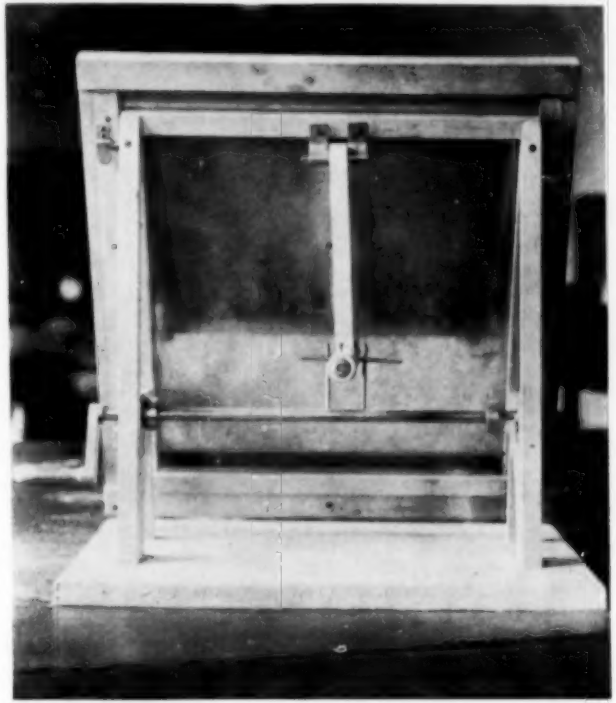
Prior to treatment, the apples carried a load averaging from .06–.17 grains of arsenic trioxide per pound of fruit, with Grimes and Wealthies containing the heaviest residues.

Residues were reduced satisfactorily by the use of the wetting agent "Alkanol B," where a concentration of 2 per cent hydrochloric acid was maintained, in all cases with the exception of the Wealthy variety. Laboratory experiments (Table 1) indicate that these residues would have been removed satisfactorily by application of heat at 100° F.

Wetting Agents Increase Rating of Commercial Washers. Repeated trials of fruit, heavily sprayed with lead arsenate and calcium caseinate, have shown that the rated capacity of washers can be increased by the use of the wetting or degumming agents herein reported, due to the rapid and effective contact established between the hydrochloric acid and lead arsenate. Moreover, the use of the above agents, when heat was not required, increased the cost of washing but one-third of a cent per bushel. Examination of fruit cleaned with any of the mixtures used and subsequently placed in common storage showed no deleterious effects after 4–6 weeks storage.



1



2

As a result of numerous experiments, it is concluded that textile wetting or degumming agents used in conjunction with dilute hydrochloric acid, or a mixture of dilute hydrochloric acid and salt, will satisfactorily remove arsenical residues from New Jersey apples receiving heavy applications of oil and lead arsenate sprays. In most cases the application of heat to the cleaning solution was unnecessary. Rapid and effective contact is established between the acid and lead arsenate by the use of wetting or degumming agents.

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THE ADHESIVE STRENGTH OF ARSENICAL INSECTICIDES

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The effectiveness of dry powder insecticides depends to a large extent upon their adhesiveness. For testing the adhesiveness of insecticides it is very important to have an accurate method which will make it possible to rapidly measure their adhesive strength.

This adhesive strength of dry powder insecticides can very easily be measured by means of the following apparatus, which at present is quite often used in entomological laboratories in Germany. This apparatus consists of two identical polished metal plates fastened to an inclined frame; to the back of the frame is attached a small hammer, which automatically strikes the frame in successive beats. To collect the falling insecticide powder, a narrow glass dish or a strip of cellophane paper is placed under the lower end of each plate. With this apparatus it is possible to compare the adhesion to the plates and the capacity to adhere when the plates vibrate with the successive beats. See Plate 54, 1 and 2.

The measurements are as follows: About 0.2 gms of weighed sample is passed through a 40 mesh screen in such a way as to distribute the dust evenly on the upper part of the plate. Ten successive beats with the hammer are then made. The amount which falls down is caught and weighed. The loss of weight is due to adhesion. This method gives comparative but very accurate results and the manipulation is very quickly accomplished.

By using the above described method we undertook the measuring of adhesive capacity of different arsenical compounds. For this study market preparations were taken. The following preparations were tested especially thoroughly:

1. Five different brands of calcium arsenate.
2. Standard lead arsenate in dry powder form.
3. A special adhesive preparation which is known on the market as hesthanol. This preparation as an active element has calcium arsenate and contains about 20 per cent of As_2O_5; the amount of water soluble As_2O_5 equals about 0.3%.
4. Copper-hesthanol which is a mixture of hesthanol and copper sulphate. It contains about 15% of As_2O_5; water soluble As_2O_5 is present in the amount of 0.03%; copper oxide equals 8%.

The results of analysis of the above mentioned insecticides are shown below.

The adhesiveness of arsenical insecticides in per cent calculated on the amount of dust which sticks to the board of the above described apparatus:

Name of Sample	Adhering	Non Adhering
Standard calcium arsenate	2.4%	97.6% (97.1–98.2)
Lead acetate	6.7%	93.3% (92.7–94.0)
Hesthanol	62.0%	37.0% (30.2–44.8)
Copper-Hesthanol	59.2%	40.8% (35.3–46.3)

A COMPARISON OF THE ADHESIVE STRENGTHS OF VARIOUS BRANDS OF CALCIUM ARSENATE

The above figure indicates the comparative adhesiveness of different brands of calcium arsenate.

In order to clear up the question whether the results of comparative adhesiveness of insecticides as to their capacity to stick to the board could be applied to leaves, the following sets of experiments were undertaken.

The metal board of the apparatus was covered with leaves, the leaves were then dusted with a weighed amount of the insecticide and ten successive beats with the hammer were made. The amount of powder which fell was collected and weighed. In this way we determined the capacity of different insecticides to stick to the leaves of cabbage, beans and Ficus.

The results of these tests are reproduced in the table given below.

Name of Leaf	Name of Compound Used	Adhesion	Non Adhesion
Cabbage	Lead arsenate	14.8%	85.2%
Cabbage	Copper-hesthanol	58.0%	42.0%
Bean	Calcium arsenate standard brand	49.5%	50.5%
Bean	Hesthanol	99.25%	0.75%
Ficus	Calcium arsenate standard brand	2.5%	97.5%
Ficus	Hesthanol	12.7%	87.3%

Summarizing the results of our experiments we can make the following statements.

1. The use of the apparatus described above is very practical and convenient for measuring the comparative adhesiveness of dry powder insecticides. By working with this apparatus we receive very stable and uniform results. In equal conditions the same insecticides give practically the same results as seen from the results of adhesiveness to the metal board of several brands of standard calcium arsenate.

2. The results obtained by measuring the adhesiveness of insecticides to the metal board could easily be applied to dusting leaves. Leaves of different kinds retain different amounts of insecticide powder, these amounts however being in the same porportion as those observed on the metal board.

Acknowledgement. It is my agreeable duty to thank cordially Prof. E. S. Reynolds, the Head of the Laboratory of Plant Physiology at the Washington University, Saint-Louis, Mo., for his important advices and the possibility to carry out these investigations.

A DISCUSSION OF SMITH AND FLANDERS' TRICHOGRAMMA FAD QUERY

By A. W. MORRILL, *Los Angeles, Cal.*

ABSTRACT

In their answer to their "trichogramma fad" query in the June issue of the Journal, Smith and Flanders ignore so many facts familiar to the majority of American entomologists who are particularly interested in the subject that no special consideration of their indiscriminate criticism should be necessary except for preventing confusion in the literature for the benefit of future workers. With this in view, a detailed discussion of all phases of the subject has not been attempted here, leaving it to the reader to examine the literature cited in connection with the facts presented in order that the trichogramma situation may be viewed in its proper perspective.

Although at the outset the criticism by Smith and Flanders appears to be limited to "some" of the work with trichogrammas, the field of attack is rapidly expanded in the next paragraph to include, apparently without exception, all the "experiments so far reported on." The description of the imaginary procedure is so overdrawn, with one or two possible exceptions, where results of preliminary experiments have been briefly reported for the benefit of other entomologists, or where somewhat careless phraseology has been used, that the reader is merely referred to the original sources for the facts. Even a casual reading of the reports available in nearly every instance plainly shows what investigators fully recognize, the need for extensive and repeated experiments as a basis for final conclusions.

DISPERSAL.—The subject of the dispersal of trichogrammas is an interesting and important one which is receiving attention by many investigators, and only a small part of the information so far acquired on the subject has been published. Such observations as reported by Smith and Flanders do not seem to justify conclusions which conflict with more extensive investigations and with practical experience in many places. No one questions the limitations of trichogrammas as regards actual flying ability unassisted by air currents, but it would be as easy to believe in the spontaneous generation of these insects as in the twelve and a half foot radius allowed by these authors for the normal sphere of influence centered at the point of liberation. In a published note concerning his experience in trichogramma colonization in 1927.[1] Flanders recorded the following observation:

"Thousands of the parasites are being liberated at the centers of infestation. A high percentage of codling-moth eggs are found to be parasitized within two weeks

[1]Jour. of Econ. Ent., vol. 20, Aug., 1927, p. 644.

after the liberation. Normal egg-parasitism is so light that it does not interfere in determining the effect of the liberations. On a large walnut tree parasites were observed stinging the moth eggs on the side opposite the point of liberation. Two parasites were found on a single egg."

From the reference to a "large" walnut tree and to the finding of two parasites on a single egg, the reader seems to have been justified in concluding that the parasites in this instance spread considerably more than twelve and a half feet from the point of liberation, and furthermore that Flanders desired to stress the point that the spread from one side to the opposite side of the tree was not accidental. The distance from one side to the opposite side of a large walnut tree in California would be three to four times the distance which Smith and Flanders would now have us believe is the normal limitation of direct trichogramma dispersal.

Among other published references to the subject of the dispersion of the trichogrammas, the observations by Steenburgh[2] should be noted. These were made in a locality where trichogrammas were not found except in and near parasitized orchards.

Unpublished records of a correspondent engaged in state experiment station work indicate a normal field of dispersal of more than twice the distance mentioned by Smith and Flanders. These observations were in orchards and the species used was the light one, the adults of which, according to Peterson[3] "will seldom fly or jump any distance." The writer's observations in regard to the dispersal of trichogrammas in cotton fields show that it is common and, in fact, usual for these insects to spread through a cotton field much faster than could be accounted for if we were to assume that the ability of the adults to spread by flight or air currents is limited to a distance of fifty or even one hundred feet from the point of liberation.

In many cotton-growing districts there are several weeks in the spring when the likelihood of trichogrammas persisting in the fields is so remote as to be negligible. While the spread of the insects through the fields after the beginning of the period during which a host egg supply is available is comparatively rapid, this natural spread cannot be depended on under normal conditions to permit of a satisfactory condition of natural control during the critical period for the crop. It seems likely that the actual field conditions which many entomologists have observed, particularly in cane and cotton fields, indicate that air currents have a decided influence on the dissemination of trichogramma parasites, both from colonization points and from points where a suitable succession of

[2]Sixtieth Ann. Rept. Ent. Soc. Ont., p. 126, 1929.
[3]Jour. N. Y. Ent. Soc., Vol. 38, p. 4, March, 1930.

host egg supplies make it possible for the parasite to exist throughout the year.

It has been found in experimental collections of insects by airplanes that small and minute insects, even wingless forms, are frequently present in the upper air currents.[4] In the arid Southwest whirlwinds of greater or less proportions are of almost daily occurrence in cotton-growing districts, and upward air currents due to convection can be demonstrated almost any day by attempting to apply poison to cotton plants between ten in the morning and four in the afternoon. No doubt similar observations have been made by other observers in other sections. While it is too early to draw any final conclusions on the subject, these and other facts previously recorded cannot be arbitrarily ignored, as Smith and Flanders would have us do.

HOST POPULATION DENSITY.—The writer is familiar with the published reports and references to the investigations conducted with trichogrammas in North America in recent years and can find no justification for the assumption that the factor of host population density has been generally disregarded. In several instances it has been mentioned in its relation to the percentage of parasitism resulting from colonizations. Even incomplete or preliminary reports generally show that the percentage figures when used for convenience have not been based upon such casual field records as Smith and Flanders have taken for granted to be the prevailing basis for conclusions.

Many host insects appear in more or less distinct broods which place trichogramma parasites at a distinct disadvantage without sufficient time to spread and multiply to a reasonably effective degree before the host population reaches its peak. The number of host eggs or density of host population in such cases is a factor which temporarily is distinctly secondary to the time factor. This situation may continue through the most critical period in the entire year for the crop. If we are merely interested in a demonstration of the ability of the parasites to eventually obtain a ninety per cent effectiveness some time "during the fall months", such a demonstration may satisfy purely scientific objectives, but should not be confused with efforts to secure practical biological control.

In the case of host insects which are present for a considerable period, such as three or four months in a season, parasitism to the extent of ten per cent in June is likely to be of more practical benefit to the crop affected than parasitism to the extent of eighty or ninety per cent in September. The value of egg parasites at any given time may not

[4]Yearbook of Agriculture, U. S. D. A., 1931, p. 322.

necessarily be expressed in the population of the parasites in a given area, or in terms of percentage. After all, final conclusions must be based upon actual field experience, regardless of theoretical considerations.

There is little in common between an experiment with an insect in a fixed environment, such as cited by Smith and Flanders, and actual conditions found in a cotton field, a cane field or a peach orchard. Host egg populations under natural or field conditions are never stationary, but on the contrary are increasing or decreasing at all times. Two or more host species frequently complicate the environmental factor and may constitute a decisive element in the acceleration of the multiplication of the parasite. This has been repeatedly recognized by previous writers. A new illustration will be cited here, possibly for the first time.

The trichogramma parasite has long been recognized as one of the most important enemies of the cotton bollworm. In certain districts in the arid Southwest this pest has for many years been recognized as a very serious menace to the cotton grower, not infrequently destroying fifty per cent or more of the crop in areas of several thousand acres, with an average annual damage estimated between five and ten per cent. For the minimum or perhaps for the average damage by this insect conconsidered by itself, it seems evident that very little can be accomplished by field colonizations except as the factor of host-egg density may be affected by the appearance of the cotton leaf worm. The bollworm egg population by itself may not afford the opportunity for the attainment of effective control by trichogrammas, but when the host egg population is greatly and very rapidly increased by the appearance of the cotton leaf worm, the situation is entirely changed.

Several writers have called attention to the opportunity for increasing the effectiveness of trichogramma parasites by the concentration of host eggs to encourage the development and maintenance of centers of parasite populations from which natural spread may take place when proper conditions exist. In the control of the cotton bollworm such concentrations may be effected by means of corn planted at intervals in the cotton field. If the bollworm in a cotton field where corn has been planted for this purpose fails to increase to a point capable of producing appreciable damage to the cotton crop, then such concentration of parasites evidently is of little or no practical value. On the other hand, where the bollworm population is capable of producing extensive damage, the use of the corn for the concentration of the host eggs and parasites may readily be a matter of very great importance. It is too early to formulate general rules under which trichogramma parasites may or may not

be utilized. Even for a given crop, conditions differ in different localities, so that colonization of the parasites which may prove beneficial in one environment may prove of questionable or of no value under different environmental conditions. The final answer in any case is not to be worked out at the desk, but rather in the field through actual experience and a study of conditions as they exist.

HYPOTHETICAL BASIS OF TRICHOGRAMMA EXPERIMENTS.—Aside from the hypotheses upon which trichogramma investigations by Smith and Flanders may have been based and for which they are at liberty to speak, it appears that these writers have little to justify their general statement that "up to the present time the work with trichogramma has been carried out on the basis of two hypotheses." Few investigators in this field would be willing to admit that their plans of investigations fit definitely into either of the two statements of hypotheses which Smith and Flanders assume to be all-inclusive. The first hypothesis, while having a basis of reason, is so stated as to constitute an absurdity. The definition of the second hypothesis is scarcely better. It is unnecessary to say more at this time than that every host of trichogramma, control of which is desired, presents a problem distinct from every other host and complicated with seasonal and other variations in host species and host egg populations, and that there seems to be no reason to assume that the various investigators in planning their work have not given due consideration to the effects of natural increases from timely liberations of the parasites, as well as the direct first-generation effects of the parasites on the hosts. Both factors are involved in practically every instance with the emphasis on one or the other, according to circumstances. Obviously, the main object in view in practically all cases has been the determination of the practicability of increasing the usefulness of trichogrammas through mass liberations at opportune times, rather than the attempt to establish any special hypothesis.

PERCENTAGE OF PARASITISM.—No one can question the statement, "Percentages of parasitism, however, do not necessarily measure the practical results of parasite colonizations." While in a few public references the results of liberations in experimental work may have been expressed in percentages, it is, as a rule, obvious that no final conclusions as to practical results are being based on such figures, and it seems only fair to the various workers to assume, when comparisons are made on the basis of percentages, that host populations are comparable between experimental and check fields or orchards.

ABILITY OF TRICHOGRAMMAS TO EXIST CONTINUOUSLY IN GIVEN LOCALITIES.—Two statements by Smith and Flanders occurring in

different paragraphs of their article may be brought together for the purpose of this discussion. First they state: "There is not the slightest doubt that Trichogramma successfully over-winters in host eggs as far north as Canada." In a later paragraph they make the statement that "the nucleus of a colony is practically always present, and, given a favorable environment, its abundance in a general way becomes inversely proportional to the distance separating the individuals of its host species. In other words, it is determined by the density of the host population."

Experience in breeding trichogrammas in insectaries has shown considerable difference between the light and dark species as regards ability to withstand refrigeration in the immature stages.[5] Tests between strains of the species originating in different localities are under way. The ability of trichogrammas to persist in many localities throughout the year is known to be dependent on a proper succession of host insects, and there is very strong evidence that the insect becomes entirely extinct throughout considerable areas each year.

The natural parasitism of the eggs of the European corn-borer in the region near the Great Lakes is stated by a good authority to be almost negligible, whereas, in certain adjoining higher elevations to the south, with a greater diversity of vegetation, and consequently a greater diversity of host insects, the percentage of egg parasitism of the corn-borer is quite high. The parasitism in the first-mentioned region may result chiefly from a secondary spread by air currents.

The condition which exists in this large area is paralleled in smaller units everywhere that the trichogramma parasites are found. It has been reported by Hinds and Spencer in Louisiana,[6] where they have found no parasitism of cane borer eggs until late in the season in a number of cases, and the condition also has been noted by the writer in cotton fields in Arizona and New Mexico. In the case of the most destructive outbreak of the cotton bollworm so far observed by the writer, near Gila Bend, Arizona, 1923, where the average loss from this pest on a ranch comprising about six thousand acres was not less than one-half bale per acre, extensive search for evidence of trichogramma parasitism of the eggs failed to result in the finding of a single parasitized egg or remains of a parasitized egg. In fact, as a result of a special investigation of the problem, a report was submitted to the operators of the farm to the effect that the outbreak by the bollworm probably was primarily due to the absence of the trichogramma parasite.

[5]Peterson, Alvah, Jour. Econ. Ent. Vol. 24, p. 1070–1074, 1931.
[6]Jour. Econ. Ent., Vol. 21, p. 274, 1928; Vol. 22, p. 635, 1929.

If we disregard the interests of the individual farmers, we may be satisfied with the assumption that trichogramma parasites are "practically always present," but Farmer Jones is not likely to be benefited much in a practical way by the nucleus of a colony of trichogrammas which may over-winter on the farm of Farmer Smith located ten miles away.

CALIFORNIA EXPERIENCE WITH TRICHOGRAMMA.—The writer believes he is justified in challenging the implications by Smith and Flanders that extensive experiments have been conducted in California with trichogramma which are distinctly discouraging to the hope of using this parasite in a practical way. The reader is referred to Flanders' reports of his experiments conducted with the walnut codling moth at Saticoy, California, in 1928–29.[7] Since the conclusion of this work it is fair to say that practically nothing of importance has been done in the State of California with mass liberations of trichogramma.

The experiments reported by Flanders cannot properly be regarded as of anything but a preliminary nature. A careful study of the data published by him would appear to many entomologists as distinctly encouraging. In the report of his liberation of trichogramma in walnut orchards in 1927, Flanders stated: "The effect of the release of trichogramma was to increase the percentage of parasitism in three weeks from less than one per cent up to as high as 52.4 per cent on the most highly infested trees. In six walnut trees liberations averaging 16,666 per tree resulted in parasitism averaging 36.4 per cent, ranging from 19.5 per cent to 52.4 per cent (p. 497). Also: "In the control of the codling moth on apple trees, the first effort will be to substitute trichogramma for the cover spray of applications of lead arsenate, and thus eliminate the arsenical residue problem. The basis for commercial control by means of this parasite is mass production at a low cost." (p. 499)

Referring to the work so far done in California, considering the wide publicity given to trichogramma and its commercial possibilities from 1927 to 1929,[8] followed by detailed reports in scientific journals, it seems unreasonable that all the anticipations so assiduously encouraged should be destroyed in 1931 with a trite unexplained assertion to the effect that the experiments with trichogramma in California "have not been encouraging." Possibly there were walnut growers looking for spectacular results who became discouraged, but the detailed results as reported by Flanders speak for themselves.

[7]Hilgardia, Cal. Agr. Exp. Sta., Vol. 4, No. 16, 1930.

[8]Florists' Exchange 66, 9, 727–728, 1927; Science News Letter, Vol. 15, No. 422, pp. 289 to 292, May 11, 1929; Pacific Rural Press 118, 82, 1929; California Garden 29, 14, 16, 1929.

COMMERCIAL WORK WITH TRICHOGRAMMA.—As in the case of entomological investigations conducted by official agencies, commercial entomological work in its various branches is entitled to be judged on its merits. In viewing with alarm the tendencies in trichogramma work, it would have been more to the point if Smith and Flanders had referred to specific instances. Possibly they had some objectionable commercial project in mind in their references to this phase of the subject. If so, and their remarks apply to any such, the general objects in view may be accepted as generally meritorious.

Since the writer is conducting a commercial insectary where trichogramma parasites are produced, it seems proper to show how such commercial work may be limited within the bounds of ethical standards which, as the reader can judge, are not inferior to the prevailing standards in non-commercial work. Commercial entomological work must necessarily be based upon a certain amount of advertising of some kind. In December, 1930, a trichogramma price list for 1931 was prepared and mailed to a limited number of members of the Association of Economic Entomologists, who, it was thought, might be interested in securing supplies of these parasites for investigations, and also in order that entomologists might refer growers in certain instances to a source of supply. In practice this price list was not sent to growers except on request, or reference from other entomologists. No attempt has been made to develop a general demand for the parasites for the many miscellaneous host insects against which their use has been suggested by other writers.[9] The following extracts from letters written to growers interested in the use of trichogramma parasites are self-explanatory:

"I have had no personal experience with the Oriental moth and would have to make suggestions based upon the experience of entomologists in ——— and ——— . . . . Dr. ——— writes that they regard the results of their experience with the Trichogrammas as very promising, but naturally in experimental work of this kind it is necessary to repeat experiments many times before considering the investigation as closed. From your standpoint I presume that you feel that it is necessary to do something and that it will be worth while to try out the most promising line of control, even though entomologists have not completed their investigations. As far as I am concerned, I try to state the facts to those who are interested in trying the Trichogrammas against various insects, without encouraging anyone to believe that he will find these parasites will prove a one hundred per cent solution of the problem." (From letter to Illinois fruit grower.)

"I have yours of the 1st, and as I have not been recommending the Trichogrammas for the codling moth I would prefer to correspond with certain entomologists in different parts of the country before suggesting a program for you. I doubt if any

[9]Hilgardia, Vol. 4, No. 16, p. 498–499

good, clear-cut demonstration has ever been made as to the value of these parasites against the codling moth." (From letter to Colorado apple-orchard owner.)

"When from ten to fifty or a hundred corn-ear worm eggs are laid on the silk of each ear of corn, there is a very high mortality of the worms as a result of their cannibalistic habits. . . . The question arises whether egg parasites which may be very successful against the same insect in the cotton field would be equally effective in a field of green corn. In a cotton field if 90 per cent of the eggs are destroyed by the parasites there is a very definite benefit to the crop. In a corn field, on the other hand, if the parasites destroy nine out of ten eggs, the ten per cent which hatch in a normal manner would be sufficient to cause as much damage as would the entire 100 per cent. This is due to the fact that the more worms present hatching from eggs laid on the silk of an ear of corn, the more opportunity for cannibalism." (From letter to Alabama shipper of green corn.)

Attention has already been directed to the fact that in different localities various circumstances, other than the abundance of a host insect, may govern the practical utilization of the trichogramma parasites. In the case of cotton, for example, it was pointed out that the writer's observations have led him to conclude tentatively, at least, that trichogramma parasites can be used in limited areas in the arid Southwest where proper environmental conditions exist.

Going a step farther, the practicability of utilizing trichogrammas may be dependent on or closely related to incidental benefits from the procedure followed. In the case of cotton, extensive losses occur each year in certain sections, as a result of leaf worm infestation, which might have been greatly minimized, both as regards direct damage to the crop and cost of control measures, by timely action during the incipiency of the infestation. In Arizona and New Mexico particularly, the leaf worm appears in leading cotton districts nearly every year from limited beginnings which may be discovered by means of timely field inspections during July and August. The discovery of an incipient infestation of this pest offers an opportunity to the grower to adopt relatively inexpensive control measures at a time when oversight or neglect will almost inevitably lead to heavy damage or to heavy expense for applying poisons. Too frequently the expense for the applications of poison represents almost complete waste, since by the time active steps are begun the greater part of the damage has already been accomplished.

For the purpose of locating incipient infestations of the leaf worm, if for no other reason, cotton growers in Arizona and New Mexico are justified in maintaining close surveillance of their crops, particularly during July and August. This surveillance, as has been pointed out, has an intrinsic value to the grower. This value in itself is sufficient to offset the nominal cost of trichogramma parasites and their distribution in the fields. Observations, however, in many parasitized fields in comparison

with check fields have shown a decided and satisfactory practical benefit to the grower from the increased parasitic control of the bollworm and the leaf worm, independent of the incidental benefits from field inspections conducted in connection with the parasite-distributing work.

If an intelligent cotton farmer, conversant with the known facts concerning the value of trichogramma parasites in the protection of his special crop, could by any reasonable and practicable cultural procedure protect trichogramma parasites during the winter and spring months so that there would be a gradual appearance of the adults in his cotton fields from the time of the first appearance of host eggs through the critical period for the crop, few would question the advisability of a grower adopting such procedure for this purpose.

In view of the very high rating which for many years has been accorded trichogramma parasites in the control of pests ranking among the most destructive to the cotton crop, and in view of the fact that practically every step in the production of this crop involves the taking of risks frequently representing the difference between a possible profit or loss at the end of the season, the grower who cannot afford to assume the risk of excessive damage which so frequently results from the absence or extreme scarcity of trichogramma parasites during or just preceding the critical period for crop production, may reasonably adopt a practice of eliminating this particular risk where conditions are favorable by having trichogramma parasites introduced in all parts of his cotton field at intervals of a few days throughout the growing season, thus, at least, insuring the existence of nuclei for the multiplication and spread of these valuable parasites, if and when serious damage to his crop is threatened. It would be impossible to find any other risk of the cotton-grower comparable in importance to this which can be eliminated at such slight expense or effort.

COMMON NAMES OF INSECTS APPROVED FOR GENERAL USE BY THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

The Committee on Nomenclature, in conformity with instructions received at the 43d annual meeting of the American Association of Economic Entomologists, has brought together the common names so far approved by the association and has added thereto, the names which received the necessary vote for adoption this year.

This list supersedes and suppresses all previous lists, and the American Association of Economic Entomologists strongly urges that its

members and such others that are in sympathy with its policy, use every effort to have these names used in all publications emanating from the institutions with which they are connected.

INSECTS LISTED BY COMMON NAMES

Achemon sphinx.....*Pholus achemon* Drury
Alaska spruce beetle.....*Dendroctonus borealis* Hopk.
Alder flea beetle.....*Haltica bimarginata* Say
Alfalfa caterpillar.....*Eurymus eurytheme* Bdv.
Alfalfa gall midge.....*Asphondylia websteri* Felt
Alfalfa looper.....*Autographa californica* Speyer
Alfalfa weevil.....*Hypera postica* Gyll.
Allegheny spruce beetle.....*Dendroctonus punctatus* Lec.
American cockroach.....*Periplaneta americana* L.
American dagger moth.....*Acronycta americana* Harr.
American dog tick.....*Dermacentor variabilis* Say
American grasshopper.....*Schistocerca americana* Drury
Augoumois grain moth.....*Sitotroga cerealella* Oliv.
Angular-winged katydid.....*Microcentrum retinerve* Burm.
Apple and thorn skeletonizer.....*Hemerophila pariana* Clerck
Apple aphid.....*Aphis pomi* DeG.
Apple bark miner.....*Gracilaria elotella* Busck
Apple curculio.....*Tachypterellus quadrigibbus* Say
Apple flea weevil.....*Orchestes pallicornis* Say
Apple fruit miner.....*Marmara pomonella* Busck
Apple fruit moth.....*Argyresthia conjugella* Zell.
Apple grain aphid.....*Rhopalosiphum prunifoliae* Fitch
Apple leafhopper.....*Empoasca maligna* Walsh
Apple leaf skeletonizer.....*Psorosina hammondi* Riley
Apple leaf trumpet miner.....*Tischeria malifoliella* Clem.
Apple maggot.....*Rhagoletis pomonella* Walsh
Apple redbug.....*Lygidea mendax* Reut.
Apple seed chalcid.....*Syntomaspis druparum* Boh.
Apple sucker.....*Psyllia mali* Schmid.
Apple twig beetle.....*Hypothenemus hispidulus* Lec.
Apple twig borer.....*Amphicerus bicaudatus* Say
Arborvitae leaf miner.....*Argyresthia thuiella* Pack.
Argentine ant.....*Iridomyrmex humilis* Mayr
Argus tortoise beetle.....*Chelymorpha cassidea* Fab.
Arizona cotton stainer.....*Dysdercus mimus* Say
Arizona pine beetle.....*Dendroctonus arizonicus* Hopk.
Army cutworm.....*Chorizagrotis auxiliaris* Grote
Armyworm.....*Cirphis unipuncta* Haw.
Artichoke plume moth.....*Platyptilia carduidactyla* Riley
Ash borer.....*Podosesia fraxini* Lugger
Ash-gray blister beetle.....*Macrobasis unicolor* Kby.
Asiatic beetle.....*Anomala orientalis* Waterh.
Asiatic rice borer.....*Chilo simplex* Butl.
Asparagus beetle.....*Crioceris asparagi* L.

Asparagus miner.....*Agromyza simplex* Loew
Australian cockroach.....*Periplaneta australasiae* Fab.
Australian-pine borer.....*Chrysobothris tranquebarica* Gmel.
Avocado whitefly.....*Trialeurodes floridensis* Quaint.

Bagworm.....*Thyridopteryx ephemeraeformis* Haw.
Bald-faced hornet.....*Vespula maculata* L.
Balsam twig aphid.....*Mindarus abietinus* Koch
Banana root borer.....*Cosmopolites sordidus* Germ.
Banded cucumber beetle.....*Diabrotica balteata* Lec.
Banded flea beetle.....*Systena taeniata* Say
Banded woolly bear.....*Isia isabella S. & A.*
Barnacle scale.....*Ceroplastes cirripediformis* Comst.
Bean aphid.....*Aphis rumicis* L.
Bean leaf beetle.....*Cerotoma trifurcata* Forst.
Bean leaf roller.....*Goniurus proteus* L.
Bean thrips.....*Heliot' rips fasciatus* Perg.
Bean weevil.....*Acanthoscelides obtectus* Say
Bedbug.....*Cimex lectularius* L.
Beech scale.....*Cryptococcus fagi* Baer.
Beet armyworm.....*Laphygma exigua* Hbn.
Beet leaf beetle.....*Monoxia puncticollis* Say
Beet leafhopper.....*Eutettix tenellus* Bak.
Beet webworm.....*Loxostege sticticalis* L.
Bertha armyworm.....*Barathra configurata* Walk.
Birch skeletonizer.....*Bucculatrix canadensisella* Chamb.
Bird tick.....*Haemaphysalis cinnabarina* Koch
Black army cutworm.....*Agrotis fennica* Tausch.
Black blister beetle.....*Epicauta pennsylvanica* DeG.
Black carpenter ant.....*Camponotus herculeanus pennsylvanicus* DeG.
Black carpet beetle.....*Attagenus piceus* Oliv.
Black cherry aphid.....*Myzus cerasi* Fab.
Black cherry fruit fly.....*Rhagoletis fausta* O. S.
Black citrus aphid.....*Toxoptera aurantiae* Koch
Black cutworm.....*Agrotis ypsilon* Rott.
Black-headed fireworm.....*Rhopobota naevana* Hbn.
Black Hills beetle.....*Dendroctonus ponderosae* Hopk.
Black-horned tree cricket.....*Oecanthus nigricornis* Walk.
Black horse fly.....*Tabanus atratus* Fab.
Black ladybeetle.....*Rhizobius ventralis* Er.
Black-legged tortoise beetle.....*Jonthonota nigripes* Oliv.
Black peach aphid.....*Anuraphis persicae-niger* Smith
Black pecan aphid.....*Myzocallis fumipennellus* Fitch
Black scale.....*Saissetia oleae* Bern.
Black swallowtail.....*Papilio polyxenes* Fab.
Black thread scale.....*Ischnaspis longirostris* Sign.
Black turpentine beetle.....*Dendroctonus terebrans* Oliv.
Black vine weevil.....*Brachyrhinus sulcatus* Fab.

Blood-sucking conenose.....*Triatoma sanguisuga* Lec.
Blueberry flea beetle.....*Haltica torquata* Lec.
Blueberry maggot.....*Rhagoletis pomonella* Walsh
Body louse.....*Pediculus humanus corporis* DeG.
Boll weevil.....*Anthonomus grandis* Boh.
Boll worm.....*Heliothis bsoleta* Fab.
Booklouse.....*Troctes divinatoria* Mull.
Boxelder aphid.....*Periphyllus negundinis* Thos.
Boxelder bug.....*Leptocoris trivittatus* Say
Boxelder leaf roller.....*Gracilaria negundella* Cham.
Boxelder twig borer.....*Proteoteras willingana* Kearf.
Boxwood leaf miner.....*Monarthropalpus buxi* Labou.
Boxwood psyllid.....*Psyllia buxi* L.
Bristly cutworm.....*Polia renige a* Steph.
Bristly rose slug.....*Cladius isomerus* Nort.
Broad-bean weevil.....*Bruchus rufimanus* Boh.
Bronze birch borer.....*Agrilus anxius* Gory
Bronzed cutworm.....*Nephelodes emmedonia* Cram.
Brown chicken louse.....*Goniodes dissimilis* Nitz.
Brown dog tick.....*Rhipicephalus sanguinius* Latr.
Brown salt-marsh mosquito.....*Aedes cantator* Coq.
Brown spider beetle.....*Ptinus brunneus* Dufts.
Brown-tail moth.....*Nygmia phaeorrhoea* Don.
Brown winter tick.....*Dermacentor nigrolineatus* Pack.
Bruce's spanworm.....*Rachela bruceata* Hulst
Buck moth.....*Hemileuca maia* Drury
Buffalo treehopper.....*Ceresa bubalus* Fab.
Bulb mite.....*Rhizoglyphus hyacinthi* Bdv.
Bumble flower beetle.....*Euphoria inda* L.

Cabbage aphid.....*Brevicoryne brassicae* L.
Cabbage curculio.....*Ceutorhynchus rapae* Gyll.
Cabbage looper.....*Autographa brassicae* Riley
Cabbage maggot.....*Hylemyia brassicae* Bouche
Cabbage seed-stalk curculio.....*Ceutorhynchus quadridens* Panz.
Cabbage webworm.....*Hellula undalis* Fab.
Cactus scale.....*Diaspis echinocacti* Bouche
Cadelle.....*Tenebroides mauritanicus* L.
Calico scale.....*Lecanium cerasorum* Ckll.
California harvester ant.....*Pogonomyrmex californicus* Buckl.
California oak worm.....*Phryganidia californica* Pack.
California pear slug.....*Micronematus californicus* Marlatt
California red scale.....*Chrysomphalus aurantii* Mask.
California tent caterpillar.....*Malacosoma californicus* Pack.
Camphor scale.....*Pseudaonidia duplex* Ckll.
Camphor thrips.....*Cryptothrips floridensis* Watson
Carolina grasshopper.....*Dissosteira carolina* L.
Carolina mantis.....*Stagmomantis carolina* Johan.
Carpenter bee.....*Xylocopa virginica* Drury

Carpenter worm ..... *Prionoxystus robiniae* Peck
Carpet beetle ..... *Anthrenus scrophulariae* L.
Carpet moth ..... *Trichophaga tapetzella* L.
Carrot beetle ..... *Ligyrus gibbosus* DeG.
Carrot rust fly ..... *Psila rosae* Fab.
Case-bearing clothes moth ..... *Tinea pellionella* L.
Castor bean tick ..... *Ixodes ricinus* L.
Catalpa midge ..... *Itonida catalpae* Comst.
Catalpa sphinx ..... *Ceratomia catalpae* Bdv.
Cat flea ..... *Ctenocephalides felis* Bouche
Cat follicle mite ..... *Demodex cati* Megn.
Cat louse ..... *Felicola subrostrata* Nitz.
Cattle biting louse ..... *Bovicola bovis* Nitz.
Cattle follicle mite ..... *Demodex bovis* Stiles
Cattle tick ..... *Boophilus annulatus* Say
Cecropia moth ..... *Platysamia cecropia* L.
Celery looper ..... *Autographa falcifera* Kby.
Celery worm ..... *Papilio polyxenes* Fab.
Chaff scale ..... *Parlatoria pergandei* Comst.
Chain-spotted geometer ..... *Cingilia catenaria* Drury
Changa ..... *Scapteriscus vicinus* Scudd.
Cheese skipper ..... *Piophila casei* L.
Cherry fruit fly ..... *Rhagoletis cingulata* Loew
Cherry fruit worm ..... *Grapholitha packardi* Zell.
Cherry leaf beetle ..... *Galerucella cavicollis* Lec.
Cherry maggot ..... *Rhagoletis cingulata* Loew
Cherry scale ..... *Aspidiotus forbesi* Johns.
Chestnut weevil ..... *Curculio rectus* Say
Chicken body louse ..... *Eomenacanthus stramineum* Nitz.
Chicken head louse ..... *Lipeurus heterographus* Nitz.
Chicken mite ..... *Dermanyssus gallinae* L.
Chigger ..... *Trombicula irritans* Riley
Chigoe ..... *Tunga penetrans* L.
Chinch bug ..... *Blissus leucopterus* Say
Chinese mantis ..... *Tenodera sinensis* Sauss.
Chrysanthemum aphid ..... *Macrosiphoniella sanborni* Gill.
Chrysanthemum gall midge ..... *Diarthronomyia hypogaea* Loew
Chrysanthemum leaf miner ..... *Napomyza chrysanthemi* Kowarz
Cicadas ..... *Cicadidae* spp.
Cigar case bearer ..... *Coleophora fletcherella* Fern.
Cigarette beetle ..... *Lasioderma serricorne* Fab.
Citrophilus mealybug ..... *Pseudococcus gahani* Green
Citrus blackfly ..... *Aleurocanthus woglumi* Ashby
Citrus mealybug ..... *Pseudococcus citri* Risso
Citrus rust mite ..... *Phyllocoptes oleivorus* Ashm.
Citrus whitefly ..... *Dialeurodes citri* Ashm.
Clear-winged grasshopper ..... *Camnula pellucida* Scudd.
Clouded sulphur ..... *Eurymus philodice* Godt.
Cloudy-winged whitefly ..... *Dialeurodes citrifolii* Morg.

Clover aphid.....*Anuraphis bakeri* Cowan
Clover cutworm.....*Scotogramma trifolii* Rott.
Clover hay worm.....*Hypsopygia costalis* Fab.
Clover head caterpillar.....*Grapholitha interstinctana* Clem.
Clover head weevil.....*Tychius picirostris* Fab.
Clover leaf midge.....*Dasyneura trifolii* Loew
Clover leaf weevil.....*Hypera punctata* Fab.
Clover mite.....*Bryobia praetiosa* Koch
Clover root borer.....*Hylastinus obscurus* Marsham
Clover root curculio.....*Sitona hispidula* Fab.
Clover seed chalcid.....*Bruchophagus funebris* How.
Clover seed midge.....*Dasyneura leguminicola* Lint.
Clover stem borer.....*Languria mozardi* Latr.
Cluster fly.....*Pollenia rudis* Fab.
Cocoanut leaf roller.....*Omiodes blackburni* Butl.
Cocoanut mealybug.....*Pseudococcus nipae* Mask.
Codling moth.....*Carpocapsa pomonella* L.
Coffee-bean weevil.....*Araecerus fasciculatus* DeG.
Colorado pine beetle.....*Dendroctonus approximatus* Dietz
Colorado potato beetle.....*Leptinotarsa decemlineata* Say
Columbine borer.....*Papaipema purpurifascia* G. & R.
Columbine leaf miner.....*Phytomyza aquilegiae* Hardy
Common cattle grub.....*Hypoderma lineatum* DeVill.
Common red spider.....*Tetranychus telarius* L.
Confused flour beetle.....*Tribolium confusum* Duv.
Convergent ladybeetle.....*Hippodamia convergens* Guer.
Corn billbugs.....*Calendra* spp. (*Sphenophorus* spp.)
Corn blotch leaf miner.....*Agromyza parvicornis* Loew
Corn ear worm.....*Heliothis obsoleta* Fab.
Cornfield ant.....*Lasius niger americana* Emery
Corn flea beetle.....*Chaetocnema pulicaria* Melsh.
Corn leaf aphid.....*Aphis maidis* Fitch
Corn root aphid.....*Anuraphis maidi-radicis* Forbes
Corn root webworm.....*Crambus caliginosellus* Clem.
Corn root worm.....*Diabrotica longicornis* Say
Corn silk beetle.....*Luperodes brunneus* Crotch
Cotton aphid.....*Aphis gossypii* Glov.
Cotton blister mite.....*Eriophyes gossypii* Bks.
Cotton flea hopper.....*Psallus seriatus* Reut.
Cotton leaf perforator.....*Bucculatrix thurberiella* Busck
Cotton leaf worm.....*Alabama argillacea* Hbn.
Cotton square borer.....*Strymon melinus* Hbn.
Cotton stainer.....*Dysdercus suturellus* H. S.
Cottonwood leaf beetle.....*Chrysomela scripta* Fab.
Cottony-cushion scale.....*Icerya purchasi* Mask.
Cottony maple scale.....*Pulvinaria vitis* L.
Cottony peach scale.....*Pulvinaria amygdali* Ckll.
Coulee cricket.....*Peranabrus scabricollis* Thos.
Cowpea aphid.....*Aphis medicaginis* Koch

Cowpea curculio.....*Chalcodermus aeneus* Boh.
Cowpea weevil.....*Callosobruchus chinensis* L.
Crab louse.....*Phthirius pubis* L.
Cranberry fruit worm.....*Mineola vaccinii* Riley
Cranberry girdler.....*Crambus hortuellus* Hbn.
Cranberry root worm.....*Rhabdopterus picipes* Oliv.
Cranberry spanworm.....*Cleora pampinaria* Guen.
Cranberry weevil.....*Anthonomus mu culus* Say
Crazy ant.....*Prenolepis longicornis* Latr.
Crepe myrtle aphid.....*Myzocallis kahawaluokalani* Kirk.
Cross-striped cabbage worm.....*Evergestis rimosalis* Guen.
Cuban-laurel thrips.....*Gynaikothrips uzeli* Zimm.
Curled rose sawfly.....*Emphytus cinctipes* Nort.
Currant aphid.....*Myzus ribis* L.
Currant borer.....*Synanthedon tipuliformis* L.
Currant bud mite.....*Eriophyes ribis* Nal.
Currant fruit fly.....*Epochra canadensis* Loew
Currant spanworm.....*Itame ribearia* Fitch
Currant stem girdler.....*Janus integer* Nort.
Cyclamen mite.....*Tarsonemus pallidus* Bks.

Dark meal worm.....*Tenebrio obscurus* Fab.
Dark-sided cutworm.....*Euxoa messoria* Harr.
Deer flies.....*Chrysops* spp.
Deodar weevil.....*Pissodes deodarae* Hopk.
Depluming mite.....*Cnemidocoptes gallinae* Raill.
Desert corn flea beetle.....*Chaetocnema ectypa* Horn
Devastating grasshopper.....*Melanoplus devastator* Scudd.
Diamond-back moth.....*Plutella maculipennis* Curt.
Differential grasshopper.....*Melanoplus differentialis* Thos.
Dingy cutworm.....*Feltia subgothica* Haw.
Dobson fly.....*Corydalis cornuta* L.
Dock sawfly.....*Ametastegia glabrata* Fall
Dog flea.....*Ctenocephalides canis* Curt.
Dog follicle mite.....*Demodex canis* Leydig
Douglas-fir beetle.....*Dendroctonus pseudotsugae* Hopk.
Dried fruit beetle.....*Carpophilus hemipterus* L.
Drug-store weevil.....*Sitodrepa panicea* L.

Ear tick.....*Ornithodoros megnini* Duges
Eastern field wireworm.....*Pheletes ectypus* Say
Eastern larch beetle.....*Dendroctonus simplex* Lec.
Eastern lubber grasshopper.....*Romalea microptera* Beauv.
Eastern spruce beetle.....*Dendroctonus piceaperda* Hopk.
Eastern tent caterpillar.....*Malacosoma americana* Fab.
Eggplant flea beetle.....*Epitrix fuscula* Crotch
Eggplant lacebug.....*Gargaphia solanii* Heid.
Eggplant leaf miner.....*Gnorimoschema glochinella* Zell.
Eight-spotted forester.....*Alypia octomaculata* Fab.

Elm borer.....*Saperda tridentata* Oliv.
Elm case bearer.....*Coleophora limosipennella* Dup.
Elm cockscomb gall.....*Colopha ulmicola* Fitch
Elm leaf beetle.....*Galerucella xanthomelaena* Schr.
Elm leaf miner.....*Kaliosysphinga ulmi* Sund.
Elm sawfly.....*Cimbex americana* Leach
Elm scurfy scale.....*Chionaspis americana* Johns.
Elm spanworm.....*Ennomos subsignarius* Hbn.
Engelmann-spruce beetle.....*Dendroctonus engelmanni* Hopk.
English grain aphid.....*Macrosiphum granarium* Kby.
Ermine moth.....*Hyponomeuta malinellus* Zell.
Euonymus scale.....*Chionaspis euonymi* Comst.
European alder leaf miner.....*Fenusa dohrnii* Tischbein
European chicken flea.....*Ceratophyllus gallinae* Schr.
European corn borer.....*Pyrausta nubilalis* Hbn.
European earwig.....*Forficula auricularia* L.
European elm scale.....*Gossyparia spuria* Mod.
European fruit lecanium.....*Lecanium corni* Bouche
European fruit scale.....*Aspidiotus ostreaeformis* Curt.
European grain moth.....*Tinea granella* L.
European peach scale.....*Lecanium persicae* Fab.
European pine shoot moth.....*Rhyacionia buoliana* Schiff.
European red mite.....*Paratetranychus pilosus* C. & F.
European spruce beetle.....*Dendroctonus micans* Klug.
Eyed click beetle.....*Alaus oculatus* L.
Eye gnats.....*Hippelates* spp.
Eye-spotted budmoth.....*Spilonota ocellana* Schiff.
Fall armyworm.....*Laphygma frugiperda* S. & A.
Fall canker worm.....*Alsophila pometaria* Harr.
Fall webworm.....*Hyphantria cunea* Drury
False chinch bug.....*Nysius ericae* Schill.
False potato beetle.....*Leptinotarsa juncta* Germ.
Fern scale.....*Hemichionaspis aspidistrae* Sign.
Field cricket.....*Gryllus assimilis* Fab.
Fiery hunter.....*Calosoma calidum* Fab.
Fig mite.....*Eriophyes fici* Essig
Fig moth.....*Ephestia cautella* Walk.
Fire ant.....*Solenopsis geminata* Fab.
Fire brat.....*Thermobia domestica* Pack.
Flat grain beetle.....*Laemophloeus minutus* Oliv.
Flat-headed apple tree borer.....*Chrysobothris femorata* Oliv.
Flood water mosquito.....*Aedes hirsuteron* Theob.
Florida harvester ant.....*Pogonomyrmex badius* Latr.
Florida red scale.....*Chrysomphalus aonidum* L.
Florida wax scale.....*Ceroplastes floridensis* Comst.
Flour beetles.....*Tribolium* spp.
Flower thrips.....*Frankliniella tritici* Fitch
Fluff louse.....*Goniocotes hologaster* Nitz.
Forage looper.....*Caenurgia erechtea* Cram.

Forest tent caterpillar.....*Malacosoma disstria* Hbn.
Fork-tailed bush katydid.....*Scudderia furcata* Bruner
Four-lined plant bug.....*Poecilocapsus lineatus* Fab.
Four-spotted tree cricket.....*Oecanthus nigricornis quadripunctatus* Beut.
Fowl tick.....*Argas miniatus* Koch
Frit fly.....*Oscinella frit* L.
Fruit tree leaf roller.....*Cacoecia argyrospila* Walk.
Fuller's rose beetle.....*Asynonychus godmani* Crotch

Gall-making maple borer.....*Xylotrechus aceris* Fisher
Garden flea hopper.....*Halticus citri* Ashm.
Garden springtail.....*Sminthurus hortensis* Fitch
Garden webworm.....*Loxostege similalis* Guen.
German cockroach.....*Blatella germanica* L.
Giant hornet.....*Vespa crabro* L.
Giant stag beetle.....*Lucanus elaphus* Fab.
Giant water bug.....*Lethocerus americanus* Leidy
Glassy cutworm.....*Sidemia devastator* Brace
Globose scale.....*Lecanium prunastri* Fonsc.
Gloomy scale.....*Chrysomphalus tenebricosus* Comst.
Glover's scale.....*Lepidosaphes gloveri* Pack.
Goat follicle mite.....*Demodex caprae* Raill.
Goldenglow aphid.....*Macrosiphum rudbeckiae* Fitch
Golden spider beetle.....*Niptus hololeucus* Fald.
Golden tortoise beetle.....*Metriona bicolor* Fab.
Gooseberry fruit worm.....*Zophodia grossulariae* Riley
Gooseberry witch-broom aphid.....*Myzus houghtonensis* Troop
Granary weevil.....*Sitophilus granaria* L.
Granulate cutworm.....*Feltia annexa* Treit.
Grape berry moth.....*Polychrosis viteana* Clem.
Grape blossom midge.....*Contarinia johnsoni* Sling.
Grape cane gall maker.....*Ampeloglypter sesostris* Lec.
Grape colaspis.....*Colaspis brunnea* Fab.
Grape curculio.....*Craponius inaequalis* Say
Grape flea beetle.....*Haltica chalybea* Ill.
Grape leaf folder.....*Desmia funeralis* Hbn.
Grape leafhopper.....*Erythroneura comes* Say
Grape leaf skeletonizer.....*Harrisina americana* Guer.
Grape mealybug.....*Pseudococcus maritimus* Ehrh.
Grape phylloxera.....*Phylloxera vitifoliae* Fitch
Grape plume moth.....*Oxyptilus periscelidactylus* Fitch
Grape root borer.....*Paranthrene polistiformis* Harr.
Grape root worm.....*Fidia viticida* Walsh
Grape sawfly.....*Erythraspides pygmaea* Say
Grape scale.....*Aspidiotus uvae* Comst.
Grape seed chalcid.....*Evoxysoma vitis* Saund.
Grape vine aphid.....*Aphis illinoisensis* Shim.
Grape whitefly.....*Trialeurodes vittatus* Quaint.

Grass thrips.....*Anaphothrips obscurus* Mull.
Gray-banded leaf roller.....*Eulia mariana* Fern.
Gray blister beetle.....*Epicauta cinerea* Forst.
Greedy scale.....*Aspidiotus camelliae* Sign.
Green budworm.....*Olethreutes variegana* Hbn.
Green bug.....*Toxoptera graminum* Rond.
Green clover worm.....*Plathypena scabra* Fab.
Green fruit worm.....*Graptolitha antennata* Walk.
Greenhouse leaf tier.....*Phlyctaenia rubigalis* Guen.
Greenhouse orthezia.....*Orthezia insignis* Dougl.
Greenhouse stone cricket.....*Tachycines asynamorus* Adel.
Greenhouse thrips.....*Heliothrips haemorrhoidalis* Bouche
Greenhouse whitefly.....*Trialeurodes vaporariorum* Westw.
Green June beetle.....*Cotinis nitida* L.
Green peach aphid.....*Myzus persicae* Sulz.
Green rose chafer.....*Dichelonyx backi* Kby.
Green scale.....*Coccus viridis* Green
Green shield scale.....*Pulvinaria psidii* Mask.
Green stink bug.....*Acrosternum hilaris* Say
Green-striped maple worm.....*Anisota rubicunda* Fab.
Gulf coast tick.....*Amblyomma maculatum* Koch
Gypsy moth.....*Porthetria dispar* L.

Hackberry nipple gall.....*Pachypsylla celtidis-mamma* Riley
Hag moth.....*Phobetron pithecium* S. & A.
Hairy spider beetle.....*Ptinus villiger* Reit.
Harlequin bug.....*Murgantia histrionica* Hahn
Hawaiian beet webworm.....*Hymenia fascialis* Cram.
Head louse.....*Pediculus humanus humanus* L.
Hellgramite.....*Corydalis cornuta* L.
Hemispherical scale.....*Saissetia hemisphaerica* Targ.
Hemlock spanworm.....*Ellopia fiscellaria* Guen.
Hessian fly.....*Phytophaga destructor* Say
Hickory bark beetle.....*Scolytus quadrispinosus* Say
Hickory horned devil.....*Citheronia regalis* Fab.
Hickory leaf roller.....*Eulia juglandana* Fern.
Hickory shuck worm.....*Laspeyresia caryana* Fitch
Hickory tussock moth.....*Halisidota caryae* Harr.
Hide beetle.....*Dermestes vulpinus* Fab.
Hog follicle mite.....*Demodex phylloides* Csokor
Hog louse.....*Haematopinus suis* L.
Holly leaf miner.....*Phytomyza ilicis* Curt.
Honey bee.....*Apis mellifera* L.
Hop aphid.....*Phorodon humuli* Schr.
Hop flea beetle.....*Psylliodes punctulata* Melsh.
Hop looper.....*Hypena humuli* Harr.
Horn fly.....*Haematobia irritans* L.
Horse biting louse.....*Trichodectes equi* L.
Horse botfly.....*Gastrophilus intestinalis* DeG.

Horse follicle mite.....*Demodex equi* Raill.
Horse-radish flea beetle.....*Phyllotreta armoraciae* Koch
House centipede.....*Scutigera forceps* Raf.
House cricket.....*Gryllus domesticus* L.
House fly.....*Musca domestica* L.
Howard's scale.....*Aspidiotus howardii* Ckll.
Human flea.....*Pulex irritans* L.

Imbricated snout beetle.....*Epicaerus imbricatus* Say
Imperial moth.....*Eacles imperialis* Drury
Imported cabbage worm.....*Ascia rapae* L.
Imported currant worm.....*Pteronidea ribesii* Scop.
Indian-meal moth.....*Plodia interpunctella* Hbn.
Introduced pine sawfly.....*Diprion simile* Htg.
Io moth.....*Automeris io* Fab.
Iris borer.....*Macronoctua onusta* Grote
Italian pear scale.....*Diaspis piricola* Del Guer.
Itch mite.....*Sarcoptes scabiei* DeG.
Ivy aphid.....*Aphis hederae* Kalt.

Japanese beetle.....*Popillia japonica* Newm.
Jeffrey pine beetle.....*Dendroctonus jeffreyi* Hopk.
Jerusalem cricket.....*Stenopelmatus fuscus* Hald.

Koa seed worm.....*Olethreutes illepida* Butl.

Lantana leaf bug.....*Teleonemia lantanae* Dist.
Lantana leaf miner.....*Cremastobombycia lantanella* Busck
Lantana plume moth.....*Platyptilia pusillodactyla* Walk.
Lantana seed fly.....*Agromyza lantanae* Froggatt
Lappet moth.....*Epicnaptera americana* Harr.
Larch case bearer.....*Coleophora laricella* Hbn.
Larch sawfly.....*Lygaeonematus erichsonii* Htg.
Larder beetle.....*Dermestes lardarius* L.
Large chestnut weevil.....*Curculio proboscideus* Fab.
Large chicken louse.....*Goniocotes gigas* Tausch.
Large duck louse.....*Trinoton querquedulae* L.
Larger canna leaf roller.....*Calpodes ethlius* Cram.
Larger Mexican pine beetle.....*Dendroctonus parallelocollis* Chap.
Large turkey louse.....*Goniodes meleagridis* L.
Larkspur leaf miner.....*Phytomyza delphiniae* Frost
Latrine fly.....*Fannia scalaris* Fab.
Lead cable borer.....*Scobicia declivis* Lec.
Leaf crumpler.....*Mineola indigenella* Zell.
Leaf-footed bug.....*Leptoglossus phyllopus* L.
Leopard moth.....*Zeuzera pyrina* L.
Lesser apple worm.....*Laspeyresia prunivora* Walsh
Lesser budmoth.....*Recurvaria nanella* Hbn.
Lesser bulb fly.....*Eumerus tuberculatus* Rond.

Lesser clover leaf weevil.....*Hypera nigrirostris* Fab.
Lesser corn stalk borer.....*Elasmopalpus lignosellus* Zell.
Lesser peach borer.....*Aegeria pictipes* G. & R.
Lilac borer.....*Podosesia syringae* Harr.
Lilac leaf miner.....*Gracilaria syringella* Fab.
Lima bean pod borer.....*Etiella zinckenella* Treit.
Lime-tree looper.....*Erannis tiliaria* Harr.
Linden borer.....*Saperda vestita* Say
Lined spittle bug.....*Philaenus lineatus* L.
Little black ant.....*Monomorium minimum* Buckl.
Little carpenter worm.....*Prionoxystus macmurtrei* Guer.
Locust borer.....*Cyllene robiniae* Forst.
Locust leaf miner.....*Chalepus dorsalis* Thunb.
Lodgepole-pine beetle.....*Dendroctonus murrayanae* Hopk.
Lone star tick.....*Amblyomma americanum* L.
Long-tailed mealybug.....*Pseudococcus adonidum* L.
Lubber grasshopper.....*Brachystola magna* Gir.
Luna moth.....*Tropaea luna* L.

Magnolia scale.....*Neolecanium cornuparvum* Thro
Mango weevil.....*Sternochetus mangiferae* Fab.
Maple leaf cutter.....*Paraclemensia acerifoliella* Fitch
Margined blister beetle.....*Epicauta marginata* Fab.
Masked hunter.....*Reduvius personatus* L.
Meadow plant bug.....*Miris dolabratus* L.
Meal moth.....*Pyralis farinalis* L.
Mealy plum aphid.....*Hyalopterus arundinis* Fab.
Mediterranean flour moth.....*Ephestia kuehniella* Zell.
Mediterranean fruit fly.....*Ceratitis capitata* Wied.
Melon aphid.....*Aphis gossypii* Glov.
Melon fly.....*Bactrocera cucurbitae* Coq.
Melon worm.....*Diaphania hyalinata* L.
Mexican bean beetle.....*Epilachna corrupta* Muls.
Mining scale.....*Howardia biclavis* Comst.
Monarch butterfly.....*Danaus menippe* Fab.
Mormon cricket.....*Anabrus simplex* Hald.
Mossy rose gall.....*Rhodites rosae* L.
Mottled tortoise beetle.....*Chirida guttata* Oliv.
Mountain pine beetle.....*Dendroctonus monticolae* Hopk.
Mourning-cloak butterfly.....*Hamadryas antiopa* L.
Mulberry whitefly.....*Tetraleurodes mori* Quaint.

Narcissus bulb fly.....*Merodon equestris* Fab.
Navel orange worm.....*Myelois venipars* Dyar
Negrobug.....*Corimelaena pulicaria* Germ.
New York weevil.....*Ithycerus noveboracensis* Forst.
Northern cattle grub.....*Hypoderma bovis* DeG.
Northern mole cricket.....*Gryllotalpa hexadactyla* Perty
Norway maple aphid.....*Periphyllus lyropictus* Kess.

Nose botfly ..... *Gastrophilus haemorrhoidalis* L.
Nutgrass armyworm ..... *Spodoptera mauritia* Bdv.
Nuttall's blister beetle ..... *Lytta nuttalli* Say

Oblique-banded leaf roller ..... *Cacoecia rosaceana* Harr.
Obscure scale ..... *Chrysomphalus obscurus* Comst.
Odorous house ant ..... *Tapinoma sessile* Say
Olive fruit fly ..... *Dacus oleae* Rossi
Onion maggot ..... *Hylemyia antiqua* Meig.
Onion thrips ..... *Thrips tabaci* Lind.
Orange dog ..... *Papilio thoas* L.
Orange maggot ..... *Anastrepha ludens* Loew
Orange-striped oak worm ..... *Anisota senatoria* S. & A.
Orange thrips ..... *Scirtothrips citri* Moult.
Orange tortrix ..... *Tortrix citrana* Fern.
Orchid fly ..... *Eurytoma orchidarum* Westw.
Oregon wireworm ..... *Melanotus oregonensis* Lec.
Oriental cockroach ..... *Blatta orientalis* L.
Oriental fruit moth ..... *Grapholitha molesta* Busck
Oriental house fly ..... *Musca vicina* Macq.
Oriental moth ..... *Cnidocampa flavescens* Walk.
Oriental rat flea ..... *Xenopsylla cheopis* Rothsch.
Oyster-shell scale ..... *Lepidosaphes ulmi* L.

Pacific Coast tick ..... *Dermacentor occidentalis* Neum.
Pacific flat-headed borer ..... *Chrysobothris mali* Horn
Painted beauty ..... *Cynthia virginiensis* Drury
Painted lady ..... *Cynthia cardui* L.
Pale-striped flea beetle ..... *Systena taeniata blanda* Melsh.
Pale tussock moth ..... *Halisidota tessellaris* S. & A.
Pale western cutworm ..... *Porosagrotis orthogonia* Morr.
Palmer worm ..... *Dichomeris ligulella* Hbn.
Pandora moth ..... *Coloradia pandora* Blake
Papaya fruit fly ..... *Toxotrypana curvicauda* Gerst.
Parlatoria date scale ..... *Parlatoria blanchardi* Targ.
Parsley worm ..... *Papilio polyxenes* Fab.
Parsnip webworm ..... *Depressaria heracliana* DeG.
Pavement ant ..... *Tetramorium caespitum* L.
Pea aphid ..... *Illinoia pisi* Kalt.
Pea moth ..... *Laspeyresia nigricana* Steph.
Pea weevil ..... *Bruchus pisorum* L.
Peach bark beetle ..... *Phthorophloeus liminaris* Harr.
Peach borer ..... *Aegeria exitiosa* Say
Peach twig borer ..... *Anarsia lineatella* Zell.
Pear fruit borer ..... *Nephopteryx rubrizonella* Rag.
Pear leaf blister mite ..... *Eriophyes pyri* Pgst.
Pear midge ..... *Contarinia pyrivora* Riley
Pear plant bug ..... *Lygus communis* Knight
Pear psylla ..... *Psyllia pyricola* Foerst.

Pear slug ..... *Eriocampoides limacina* Retz.
Pear thrips ..... *Taeniothrips inconsequens* Uzel.
Pecan budmoth ..... *Gretchena bolliana* Sling.
Pecan case bearer ..... *Mineola juglandis* LeB.
Pecan cigar case bearer ..... *Coleophora caryaefoliella* Clem.
Pecan nut case bearer ..... *Acrobasis caryae* Grote
Pecan weevil ..... *Curculio caryae* Horn
Pepper and salt moth ..... *Amphidasis cognataria* Guen.
Pepper grass beetle ..... *Galeruca externa* Say
Pepper weevil ..... *Anthonomus eugenii* Cano
Periodical cicada ..... *Magicicada* (*Tibicina*) *septendecim* L.
Persimmon psylla ..... *Trioza diospyri* Ashm.
Pharoah's ant ..... *Monomorium pharaonis* L.
Pickle worm ..... *Diaphania nitidalis* Stoll
Pigeon fly ..... *Pseudolynchia maura* Bigot
Pigeon tremex ..... *Tremex columba* L.
Pineapple scale ..... *Diaspis bromeliae* Kern.
Pineapple mealybug ..... *Pseudococcus brevipes* Ckll.
Pineapple weevil ..... *Metamasius ritchei* Mar.
Pine bark aphid ..... *Pineus strobi* Htg.
Pine butterfly ..... *Neophasia menapia* Feld.
Pine needle scale ..... *Chionaspis pinifoliae* Fitch
Pine tube moth ..... *Eulia pinatubana* Kearf.
Pink boll worm ..... *Pectinophora gossypiella* Saund.
Pistol case bearer ..... *Coleophora malivorella* Riley
Pitcher plant mosquito ..... *Wyeomyia smithii* Coq.
Pitch twig moth ..... *Petrova comstockiana* Fern.
Plains false wireworm ..... *Eleodes opaca* Say
Plum curculio ..... *Conotrachelus nenuphar* Hbst.
Plum gouger ..... *Anthonomus scutellaris* Lec.
Polyphemus moth ..... *Telea polyphemus* Cram.
Pomace fly ..... *Drosophila ampelophila* Loew
Poplar borer ..... *Saperda calcarata* Say
Potato aphid ..... *Illinoia solanifolii* Ashm.
Potato flea beetle ..... *Epitrix cucumeris* Harr.
Potato leafhopper ..... *Empoasca fabae* Harr.
Potato maggot ..... *Hylemyia trichodactyla* Rond.
Potato stalk borer ..... *Trichobaris trinotata* Say
Potato stem borer ..... *Hydroecia micacea* Esp.
Potato tuber worm ..... *Gnorimoschema operculella* Zell.
Poultry bug ..... *Haematosiphon inodorus* Duges
Prairie grain wireworm ..... *Ludius aereipennis* Kby.
Privet leaf miner ..... *Gracilaria cuculipennella* Hbn.
Promethea moth ..... *Callosamia promethea* Drury
Puget Sound wireworm ..... *Ludius suckleyi* Lec.
Purple scale ..... *Lepidosaphes beckii* Newm.
Putnam's scale ..... *Aspidiotus ancylus* Putn.
Pyriform scale ..... *Protopulvinaria pyriformis* Ckll.

Quince curculio ..... *Conotrachelus crataegi* Walsh

Rabbit louse ..... *Haematopinus ventricosus* Denny
Rabbit tick ..... *Haemaphysalis leporis-palustris* Pack.
Range caterpillar ..... *Hemileuca oliviae* Ckll.
Range crane fly ..... *Tipula simplex* Doane
Raspberry cane borer ..... *Oberea bimaculata* Oliv.
Raspberry cane maggot ..... *Hylemyia rubivora* Coq.
Raspberry fruit worm ..... *Byturus unicolor* Say
Raspberry leaf roller ..... *Exartema permundanum* Clem.
Raspberry root borer ..... *Bembecia marginata* Harr.
Raspberry sawfly ..... *Monophadnoides rubi* Harr.
Rat flea ..... *Ceratophyllus fasciatus* Bosc.
Red admiral ..... *Cynthia atlanta* L.
Red-backed cutworm ..... *Euxoa ochrogaster* Guen.
Red-banded leaf roller ..... *Eulia velutinana* Walk.
Red-banded thrips ..... *Selenothrips rubrocinctus* Giard.
Red carpenter ant ..... *Camponotus herculeanus pennsylvanicus ferrugineus* Fab.
Red date scale ..... *Phoenicococcus marlatti* Ckll.
Red harvester ant ..... *Pogonomyrmex barbatus* Mayr
Red-headed pine sawfly ..... *Neodiprion lecontei* Fitch
Red-humped caterpillar ..... *Schizura concinna* S. & A.
Red-legged flea beetle ..... *Derocrepis erythropus* Melsh.
Red-legged grasshopper ..... *Melanoplus femur-rubrum* DeG.
Red-legged ham beetle ..... *Necrobia rufipes* DeG.
Red milkweed beetle ..... *Tetraopes tetraophthalmus* Forst.
Red-necked cane borer ..... *Agrilus ruficollis* Fab.
Red-shouldered ham beetle ..... *Necrobia ruficollis* Fab.
Red-tailed tachina ..... *Winthemia quadripustulata* Fab
Red turnip beetle ..... *Entomoscelis adonidis* Pal.
Red turpentine beetle ..... *Dendroctonus valens* Lec.
Red-winged pine beetle ..... *Dendroctonus rufipennis* Kby.
Regal moth ..... *Citheronia regalis* Fab.
Resplendent shield bearer ..... *Coptodisca splendoriferella* Clem.
Rhododendron lacebug ..... *Stephanitis rhododendri* How.
Rhubarb curculio ..... *Lixus concavus* Say
Rice stalk borer ..... *Chilo plejadellus* Zinck.
Rice water weevil ..... *Lissorhoptrus simplex* Say
Rice weevil ..... *Sitophilus oryzae* L.
Ring-legged earwig ..... *Anisolabis annulipes* Lucas
Rocky Mountain grasshopper ..... *Melanoplus spretus* Uhl.
Rose aphid ..... *Macrosiphum rosae* L.
Rose chafer ..... *Macrodactylus subspinosus* Fab.
Rose curculio ..... *Rhynchites bicolor* Fab.
Rose leafhopper ..... *Typhlocyba rosae* L.
Rose midge ..... *Dasyneura rhodophaga* Coq.
Rose root gall ..... *Rhodites radicum* O. S.
Rose sawfly ..... *Caliroa aethiops* Fab.

Rose scale.....*Aulacaspis rosae* Bouche
Rosy apple aphid.....*Anuraphis roseus* Baker
Round-headed apple tree borer.....*Saperda candida* Fab.
Round-headed pine beetle.....*Dendroctonus convexifrons* Hopk.
Rust-red flour beetle.....*Tribolium ferrugineum* Fab.
Rusty plum aphid.....*Hysteroneura setariae* Thos.
Rusty tussock moth.....*Notolophus antiqua* L.

Saddle-back caterpillar.....*Sibine stimulea* Clem.
Saddled leafhopper.....*Thamnotettix clitellarius* Say
Saddled prominent.....*Heterocampa gultivitta* Walk.
Salt-marsh caterpillar.....*Estigmene acraea* Drury
Salt-marsh mosquito.....*Aedes sollicitans* Walk.
Sand wireworm.....*Horistonotus uhlerii* Horn
San Jose scale.....*Aspidiotus perniciosus* Comst.
Satin moth.....*Stilpnotia salicis* L.
Saw-toothed grain beetle.....*Oryzaephilus surinamensis* L.
Say's blister beetle.....*Pomphopoea sayi* Lec.
Say's stink bug.....*Chlorochroa sayi* Stahl
Scab mite.....*Psoroptes communis* Feurst.
Scaly-leg mite.....*Cnemidocoptes mutans* Robin
Screw worm.....*Cochliomyia macellaria* Fab.
Scurfy scale.....*Chionaspis furfura* Fitch
Seed corn beetle.....*Agonoderus pallipes* Fab.
Seed corn maggot.....*Hylemyia cilicrura* Rond.
Serpentine leaf miner.....*Agromyza pusilla* Meig.
Sheep botfly.....*Oestris ovis* L.
Sheep follicle mite.....*Demodex canis ovis* Raill.
Sheep scab mite.....*Psoroptes ovis* Her.
Sheep tick.....*Melophagus ovinus* L.
Short-nosed cattle louse.....*Haematopinus eurysternus* Nitz.
Shot-hole borer.....*Scolytus rugulosus* Ratz.
Silkworm.....*Bombyx mori* L.
Silky ant.....*Formica fusca subsericea* Say
Silky cane weevil.....*Metamasius sericeus* Oliv.
Silverfish.....*Lepisma saccharina* L.
Sinuate pear tree borer.....*Agrilus sinuatus* Oliv.
Sitka-spruce beetle.....*Dendroctonus obesus* Mann.
Six-spotted leafhopper.....*Cicadula divisa* Uhl.
Slender duck louse.....*Esthiopterum crassicorne* Scop.
Slender pigeon louse.....*Columbicola columbae* L.
Smaller Mexican pine beetle.....*Dendroctonus mexicanus* Hopk.
Small pigeon louse.....*Goniocotes bidentatus* Scop.
Smartweed borer.....*Pyrausta ainsliei* Heinr.
Smut beetle.....*Phalacrus politus* Melsh.
Snowball aphid.....*Aphis viburnicola* Gill.
Snowy tree cricket.....*Oecanthus niveus* DeG.
Soft scale.....*Coccus hesperidum* L.
Sorghum midge.....*Contarinia sorghicola* Coq.

Sorghum webworm ..... *Celama sorghiella* Riley
Southern armyworm ..... *Prodenia eridania* Cram.
Southern beet webworm ..... *Pachyzancla bipunctalis* Fab.
Southern cabbage worm ..... *Ascia protodice* B. & L.
Southern corn stalk borer ..... *Diatraea crambidoides* Grote
Southern cowpea weevil ..... *Callosobruchus maculatus* Fab.
Southern green stink bug ..... *Nezara viridula* L.
Southern pine beetle ..... *Dendroctonus frontalis* Zimm.
Southern pine sawyer ..... *Monochamus titillator* Fab.
Southwestern corn borer ..... *Diatraea grandiosella* Dyar
Southwestern pine beetle ..... *Dendroctonus barberi* Hopk.
Spanish fly ..... *Lytta vesicatoria* L.
Spinach leaf miner ..... *Pegomyia hyoscyami* Panz.
Spined soldier bug ..... *Podisus maculiventris* Say
Spiny oak worm ..... *Anisota stigma* Fab.
Spotted asparagus beetle ..... *Crioceris duodecimpunctata* L.
Spotted beet webworm ..... *Hymenia perspectalis* Hbn.
Spotted blister beetle ..... *Epicauta maculata* Say
Spotted cucumber beetle ..... *Diabrotica duodecimpunctata* Fab.
Spotted cutworm ..... *Agrotis c-nigrum* L.
Spotted tussock moth ..... *Halisidota maculata* Harr.
Spring canker worm ..... *Paleacrita vernata* Peck
Spruce aphid ..... *Aphis abietina* Walk.
Spruce budworm ..... *Harmologa fumiferana* Clem.
Spruce sawfly ..... *Neodiprion abietis* Harr.
Square-necked grain beetle ..... *Cathartus quadricollis* Guer.
Squash beetle ..... *Epilachna borealis* Fab.
Squash borer ..... *Melittia satyriniformis* Hbn.
Squash bug ..... *Anasa tristis* DeG.
Stable fly ..... *Stomoxys calcitrans* L.
Stalk borer ..... *Papaipema nebris nitela* Guen.
Steel-blue ladybeetle ..... *Orcus chalybeus* Bdv.
Sticktight flea ..... *Echidnophaga gallinacea* Westw.
Stink beetle ..... *Nomius pygmaeus* Dej.
Strawberry aphid ..... *Myzus fragaefolii* Ckll.
Strawberry crown borer ..... *Tyloderma fragariae* Riley
Strawberry crown moth ..... *Aegeria rutilans* Hy. Edw.
Strawberry flea beetle ..... *Haltica ignita* Auct.
Strawberry leaf roller ..... *Ancylis comptana* Froel.
Strawberry root aphid ..... *Aphis forbesi* Weed
Strawberry weevil ..... *Anthonomus signatus* Say
Strawberry whitefly ..... *Trialeurodes packardii* Morrill
Striped blister beetle ..... *Epicauta vittata* Fab.
Striped cucumber beetle ..... *Diabrotica vittata* Fab.
Striped cutworm ..... *Euxoa tessellata* Harr.
Striped flea beetle ..... *Phyllotreta vittata* Fab.
Striped garden caterpillar ..... *Polia legitima* Grote
Striped horse fly ..... *Tabanus lineola* Fab.
Suckfly ..... *Dicyphus minimus* Uhl.

Sucking horse louse.....*Haematopinus asini* L.
Sugar beet root aphid.....*Pemphigus betae* Doane
Sugarcane beetle.....*Euetheola rugiceps* Lec.
Sugarcane borer.....*Diatraea saccharalis* Fab.
Sugarcane leafhopper.....*Perkinsiella saccharicida* Kirk.
Sugarcane leaf roller.....*Omiodes accepta* Butl.
Sugar-maple borer.....*Glycobius speciosus* Say
Sunflower beetle.....*Zygogramma exclamationis* Fab.
Sunflower maggot.....*Straussia longipennis* Weid.
Surinam roach.....*Pycnoscelus surinamensis* L.
Swallow bug.....*Oeciacus vicarius* Horv.
Sweetpotato flea beetle.....*Chaetocnema confinis* Crotch
Sweetpotato hornworm.....*Herse cingulata* Fab.
Sweetpotato leaf miner.....*Bedellia orchilella* Wals.
Sweetpotato leaf roller.....*Pilocrocis tripunctata* Fab.
Sweetpotato vine borer.....*Omphisa anastamosalis* Guen.
Sweetpotato weevil.....*Cylas formicarius* Fab.
Sweetpotato whitefly.....*Bemisia inconspicua* Quaint.

Tahitian cocoanut weevil.....*Diocalandra taitensis* Guer.
Tarnished plant bug.....*Lygus pratensis* L.
Ten-lined June beetle.....*Polyphylla decemlineata* Say
Terrapin scale.....*Lecanium nigrofasciatum* Perg.
Thistle aphid.....*Anuraphis cardui* L.
Three-banded leafhopper.....*Erythroneura tricincta* Fitch
Three-lined potato beetle.....*Lema trilineata* Oliv.
Throat botfly.....*Gastrophilus nasalis* L.
Thurberia weevil.....*Anthonomus grandis thurberiae* Pierce
Tiger swallowtail.....*Papilio glaucus form turnus* L.
Toadbug.....*Gelastocoris oculatus* Fab.
Tobacco budworm.....*Heliothis virescens* Fab.
Tobacco flea beetle.....*Epitrix parvula* Fab.
Tobacco thrips.....*Frankliniella fusca* Hinds
Tobacco worm.....*Phlegethontius quinquemaculata* Haw.
Tomato worm.....*Phlegethontius sexta* Johan.
Tropical horse tick.....*Dermacentor nitens* Neum.
Tropical rat mite.....*Liponyssus bacoti* Hirst.
Tulip tree scale.....*Toumeyella liriodendri* Gmel.
Turkey gnat.....*Simulium meridionale* Riley
Turnip aphid.....*Rhopalosiphum pseudobrassicae* Davis
Twice-stabbed ladybeetle.....*Chilocorus bivulneris* Muls.
Twig girdler.....*Oncideres cingulatus* Say
Two-lined chestnut borer.....*Agrilus bilineatus* Web.
Two-spotted ladybeetle.....*Adalia bipunctata* L.
Two-striped grasshopper.....*Melanoplus bivittatus* Say
Two-striped walkingstick.....*Anisomorpha buprestoides* Stah

Ugly-nest caterpillar.....*Cacoecia cerasivorana* Fitch
Unicorn caterpillar.....*Schizura unicornis* S. & A.

Vagabond crambus.....*Crambus vulgivagellus* Clem.
Varied carpet beetle.....*Anthrenus verbasci* L.
Variegated cutworm.....*Lycophotia margaritosa saucia* Hbn.
Vedalia.....*Rodolia cardinalis* Muls.
Vegetable weevil.....*Listroderes obliquus* Gyll.
Velvetbean caterpillar.....*Anticarsia gemmatilis* Hbn.
Viceroy.....*Basilarchia archippus* Cram.
Violet aphid.....*Neotoxoptera violae* Perg.
Violet sawfly.....*Emphytina canadensis* Kby.

Walkingstick.....*Diapheromera femorata* Say
Walnut aphid.....*Chromaphis juglandicola* Kalt.
Walnut case bearer.....*Acrobasis juglandis* LeB.
Walnut caterpillar.....*Datana integerrima* G. & R.
Walnut husk fly.....*Rhagoletis juglandis* Cress.
Walnut scale.....*Aspidiotus juglans-regiae* Comst.
Walnut sphinx.....*Cressonia juglandis* S. & A.
Watercress leaf beetle.....*Phaedon aeruginosus* Suffr.
Watercress sowbug.....*Mancasellus brachyurus* Harger
Wax moth.....*Galleria mellonella* L.
Webbing clothes moth.....*Tineola biselliella* Hum.
Western black flea beetle.....*Phyllotreta pusilla* Horn
Western cedar borer.....*Trachykele blondeli* Mars.
Western chicken flea.....*Ceratophyllus niger* Fox
Western chinch bug.....*Blissus occiduus* Barber
Western grape root worm.....*Adoxus obscurus* L.
Western grape skeletonizer.....*Harrisina brillians* B. & McD.
Western peach borer.....*Aegeria opalescens* Hy. Edw.
Western pine beetle.....*Dendroctonus brevicomis* Lec.
Western potato flea beetle.....*Epitrix subcrinita* Lec.
Western spotted cucumber beetle.....*Diabrotica soror* Lec.
Western striped cucumber beetle.....*Diabrotica trivittata* Mann.
Western striped flea beetle.....*Phyllotreta ramosa* Crotch
Western tent caterpillar.....*Malacosoma pluvialis* Dyar
Western tussock moth.....*Hemerocampa vetusta* Bdv.
West Indian cane weevil.....*Metamasius hemipterus* L.
West Indian fruit fly.....*Anastrepha fraterculus* Wied.
Wheat head armyworm.....*Neleucania albilinea* Hbn.
Wheat joint worm.....*Harmolita tritici* Fitch
Wheat midge.....*Contarinia tritici* Kby.
Wheat stem maggot.....*Meromyza americana* Fitch
Wheat stem sawfly.....*Cephus cinctus* Nort.
Wheat straw worm.....*Harmolita grandis* Riley
Wheat wireworm.....*Agriotes mancus* Say
Wheel bug.....*Arilus cristatus* L.
White cutworm.....*Euxoa scandens* Riley
White-lined sphinx.....*Sphinx lineata* Fab.
White-marked spider beetle.....*Ptinus fur* L.
White-marked tussock moth.....*Hemerocampa leucostigma* S. & A.

White peach scale.....*Aulacaspis pentagona* Targ.
White-pine weevil.....*Pissodes strobi* Peck
Willow sawfly.....*Pteronidea ventralis* Say
Winter tick.....*Dermacentor albipictus* Pack.
W-marked cutworm.....*Agrotis unicolor* Walk.
Woolly alder aphid.....*Prociphilus tessellatus* Fitch
Woolly apple aphid.....*Eriosoma lanigera* Hausm.
Woolly elm aphid.....*Eriosoma americana* Riley
Woolly pear aphid.....*Eriosoma pyricola* Baker
Woolly whitefly.....*Aleurothrixus howardii* Quaint.

Yellow-fever mosquito.....*Aedes aegypti* L.
Yellow-headed cutworm.....*Septis arctica* Bdv.
Yellow-headed fireworm.....*Peronea minuta* Rob.
Yellow-headed spruce sawfly.....*Pachynematus ocreatus* Harr.
Yellow meal worm.....*Tenebrio molitor* L.
Yellow-necked caterpillar.....*Datana ministra* Drury
Yellow-striped armyworm.....*Prodenia ornithogalli* Guen.
Yellow woolly bear.....*Diacrisia virginica* Fab.
Yucca moth.....*Tegeticula alba* Zell.

Zebra caterpillar.....*Mamestra picta* Harr.

Insects Listed by Scientific Names

Acanthoscelides obtectus Say.....Bean Weevil
Acrobasis caryae Grote.....Pecan nut case bearer
Acronycta americana Harr.....American dagger moth
Acrosternum hilaris Say.....Green stink bug
Adalia bipunctata L.....Two-spotted ladybeetle
Adoxus obscurus L.....Western grape root worm
Aedes aegypti L.....Yellow-fever mosquito
Aedes cantator Coq.....Brown salt-marsh mosquito
Aedes hirsuteron Theob.....Flood water mosquito
Aedes sollicitans Walk.....Salt-marsh mosquito
Aegeria exitiosa Say.....Peach borer
Aegeria opalescens Hy. Edw.....Western peach borer
Aegeria pictipes G. & R.....Lesser peach borer
Aegeria rutilans Hy. Edw.....Strawberry crown moth
Agonoderus pallipes Fab.....Seed corn beetle
Agrilus anxius Gory.....Bronze birch borer
Agrilus bilineatus Web.....Two-lined chestnut borer
Agrilus ruficollis Fab.....Red-necked cane borer
Agrilus sinuatus Oliv.....Sinuate pear tree borer
Agriotes mancus Say.....Wheat wireworm
Agromyza lantanae Froggatt.....Lantana seed fly
Agromyza parvicornis Loew.....Corn blotch leaf miner
Agromyza pusilla Meig.....Serpentine leaf miner
Agromyza simplex Loew.....Asparagus miner
Agrotis c-nigrum L.....Spotted cutworm

Agrotis fennica Tausch.....Black army cutworm
Agrotis unicolor Walk.....W-marked cutworm
Agrotis ypsilon Rott.....Black cutworm
Alabama argillacea Hbn.....Cotton leaf worm
Alaus oculatus L.....Eyed click beetle
Aleurocanthus woglumi Ashby.....Citrus blackfly
Aleurothrixus howardii Quaint.....Woolly whitefly
Alsophila pometaria Harr.....Fall canker worm
Alypia octomaculata Fab.....Eight-spotted forester
Amblyomma americanum L.....Lone star tick
Amblyomma maculatum Koch.....Gulf coast tick
Ametastegia glabrata Fall.....Dock sawfly
Ampeloglypter sesostris Lec.....Grape cane gall maker
Amphicerus bicaudatus Say.....Apple twig borer
Amphidasis cognataria Guen.....Pepper and salt moth
Anabrus simplex Hald.....Mormon cricket
Anaphothrips obscurus Mull.....Grass thrips
Anarsia lineatella Zell.....Peach twig borer
Anasa tristis DeG.....Squash bug
Anastrepha fraterculus Wied.....West Indian fruit fly
Anastrepha ludens Loew.....Orange maggot
Ancylis comptana Froel.....Strawberry leaf roller
Anisolabis annulipes Lucas.....Ring-legged earwig
Anisomorpha buprestoides Stahl.....Two-striped walkingstick
Anisota rubicunda Fab.....Green-striped maple worm
Anisota senatoria S. & A.....Orange-striped oak worm
Anisota stigma Fab.....Spiny oak worm
Anomala orientalis Waterh.....Asiatic beetle
Anthonomus eugenii Cano.....Pepper weevil
Anthonomus grandis Boh.....Boll weevil
Anthonomus grandis thurberiae Pierce.....Thurberia weevil
Anthonomus musculus Say.....Cranberry weevil
Anthonomus scutellaris Lec.....Plum gouger
Anthonomus signatus Say.....Strawberry weevil
Anthrenus scrophulariae L.....Carpet beetle
Anthrenus verbasci L.....Varied carpet beetle
Anticarsia gemmatilis Hbn.....Velvetbean caterpillar
Anuraphis bakeri Cowan.....Clover aphid
Anuraphis cardui L.....Thistle aphid
Anuraphis maidi-radicis Forbes.....Corn root aphid
Anuraphis persicae-niger Smith.....Black peach aphid
Anuraphis roseus Baker.....Rosy apple aphid
Aphis abietina Walk.....Spruce aphid
Aphis forbesi Weed.....Strawberry root aphid
Aphis gossypii Glov.....Melon aphid / Cotton aphid
Aphis hederae Kalt.....Ivy aphid
Aphis illinoisensis Shim.....Grape vine aphid
Aphis maidis Fitch.....Corn leaf aphid

Aphis medicaginis Koch.....Cowpea aphid
Aphis pomi DeG.....Apple aphid
Aphis rumicis L.....Bean aphid
Aphis viburnicola Gill.....Snowball aphid
Apis mellifera L.....Honey bee
Araecerus fasciculatus DeG.....Coffee-bean weevil
Argas miniatus Koch.....Fowl tick
Argyresthia conjugella Zell.....Apple fruit moth
Argyresthia thuiella Pack.....Arborvitae leaf miner
Arilus cristatus L.....Wheel bug
Ascia protodice B. & L.....Southern cabbage worm
Ascia rapae L.....Imported cabbage worm
Asphondylia websteri Felt.....Alfalfa gall midge
Aspidiotus ancylus Putn.....Putnam's scale
Aspidiotus camelliae Sign.....Greedy scale
Aspidiotus forbesi Johns.....Cherry scale
Aspidiotus howardii Ckll.....Howard's scale
Aspidiotus juglans-regiae Comst.....Walnut scale
Aspidiotus ostreaeformis Curt.....European fruit scale
Aspidiotus perniciosus Comst.....San Jose scale
Aspidiotus uvae Comst.....Grape scale
Asynonychus godmani Crotch.....Fuller's rose beetle
Attagenus piceus Oliv.....Black carpet beetle
Aulacaspis pentagona Targ.....White peach scale
Aulacaspis rosae Bouche.....Rose scale
Autographa brassicae Riley.....Cabbage looper
Autographa californica Speyer.....Alfalfa looper
Autographa falcifera Kby.....Celery looper
Automeris io Fab.....Io moth

Bactrocera cucurbitae Coq.....Melon fly
Barathra configurata Walk.....Bertha armyworm
Basilarchia archippus Cram.....Viceroy
Bedellia orchilelle Wals.....Sweetpotato leaf miner
Bembecia marginata Harr.....Raspberry root borer
Bemisia inconspicua Quaint.....Sweetpotato whitefly
Blatta orientalis L.....Oriental cockroach
Blattella germanica L.....German cockroach
Blissus leucopterus Say.....Chinch bug
Blissus occiduus Barber.....Western chinch bug
Bombyx mori L.....Silkworm
Boophilus annulatus Say.....Cattle tick
Bovicola bovis Nitz.....Cattle biting louse
Brachyrhinus sulcatus Fab.....Black vine weevil
Brachystola magna Gir.....Lubber grasshopper
Brevicoryne brassicae L.....Cabbage aphid
Bruchophagus funebris How.....Clover seed chalcid
Bruchus pisorum L.....Pea weevil
Bruchus rufimanus Boh.....Broad-bean weevil

Bryobia praetiosa Koch.....Clover mite
Bucculatrix canadensisella Chamb.....Birch skeletonizer
Bucculatrix thurberiella Busck.....Cotton leaf perforator
Byturus unicolor Say.....Raspberry fruit worm

Cacoecia argyrospila Walk.....Fruit tree leaf roller
Cacoecia cerasivorana Fitch.....Ugly-nest caterpillar
Cacoecia rosaceana Harr.....Oblique-banded leaf roller
Caenurgia erechtea Cram.....Forage looper
Calendra spp. (*Sphenophorus* spp.).....Corn billbugs
Caliroa aethiops Fab.....Rose sawfly
Callosamia promethea Drury.....Promethea moth
Callosobruchus chinensis L.....Cowpea weevil
Callosobruchus maculatus Fab.....Southern cowpea weevil
Calosoma calidum Fab.....Fiery hunter
Calpodes ethlius Cram.....Larger canna leaf roller
Camnula pellucida Scudd.....Clear-winged grasshopper
Camponotus herculeanus pennsylvanicus DeG.....Black carpenter ant
Camponotus herculeanus pennsylvanicus ferrugineus Fab.....Red carpenter ant
Carpocapsa pomonella L.....Codling moth
Carpophilus hemipterus L.....Dried fruit beetle
Cathartus quadricollis Guer.....Square-necked grain beetle
Celama sorghiella Riley.....Sorghum webworm
Cephus cinctus Nort.....Wheat stem sawfly
Ceratitis capitata Wied.....Mediterranean fruit fly
Ceratomia catalpae Bdv.....Catalpa sphinx
Ceratophyllus fasciatus Bosc.....Rat flea
Ceratophyllus gallinae Schr.....European chicken flea
Ceratophyllus niger Fox.....Western chicken flea
Ceresa bubalus Fab.....Buffalo treehopper
Ceroplastes cirripediformis Comst.....Barnacle scale
Ceroplastes floridensis Comst.....Florida wax scale
Cerotoma trifurcata Forst.....Bean leaf beetle
Ceutorhynchus quadridens Panz.....Cabbage seed-stalk curculio
Ceutorhynchus rapae Gyll.....Cabbage curculio
Chaetocnema confinis Crotch.....Sweetpotato flea beetle
Chaetocnema ectypa Horn.....Desert corn flea beetle
Chaetocnema pulicaria Melsh.....Corn flea beetle
Chalcodermus aeneus Boh.....Cowpea curculio
Chalepus dorsalis Thunb.....Locust leaf miner
Chelymorpha cassidea Fab.....Argus tortoise beetle
Chilocorus bivulnerus Muls.....Twice-stabbed ladybeetle
Chilo plejadellus Zinck.....Rice stalk borer
Chilo simplex Butl.....Asiatic rice borer
Chionaspis americana Johns.....Elm scurfy scale
Chionaspis euonymi Comst.....Euonymus scale
Chionaspis furfura Fitch.....Scurfy scale

Chionaspis pinifoliae Fitch.....Pine needle scale
Chirida guttata Oliv.....Mottled tortoise beetle
Chlorochroa sayi Stahl.....Say's stink bug
Chorizagrotis auxiliaris Grote.....Army cutworm
Chromaphis juglandicola Kalt.....Walnut aphid
Chrysobothris femorata Oliv.....Flat-headed apple tree borer
Chrysobothris mali Horn.....Pacific flat-headed borer
Chrysobothris tranquebarica Gmel.....Australian-pine borer
Chrysomela scripta Fab.....Cottonwood leaf beetle
Chrysomphalus aonidum L.....Florida red scale
Chrysomphalus aurantii Mask.....California red scale
Chrysomphalus obscurus Comst.....Obscure scale
Chrysomphalus tenebricosus Comst.....Gloomy scale
Chrysops spp.....Deer flies
Cicadidae spp.....Cicadas
Cicadula divisa Uhl.....Six-spotted leafhopper
Cimbex americana Leach.....Elm sawfly
Cimex lectularius L.....Bedbug
Cingilia catenaria Drury.....Chain-spotted geometer
Cirphis unipuncta Haw.....Armyworm
Citheronia regalis Fab.....Hickory horned devil; Regal moth
Cladius isomerus Nort.....Bristly rose slug
Cleora pampinaria Guen.....Cranberry spanworm
Cnemidocoptes gallinae Raill.....Depluming mite
Cnemidocoptes mutans Robin.....Scaly-leg mite
Cnidocampa flavescens Walk.....Oriental moth
Coccus hesperidum L.....Soft scale
Coccus viridis Green.....Green scale
Cochliomyia macellaria Fab.....Screw worm
Colaspis brunnea Fab.....Grape colaspis
Coleophora caryaefoliella Clem.....Pecan cigar case bearer
Coleophora fletcherella Fern.....Cigar case bearer
Coleophora laricella Hbn.....Larch case bearer
Coleophora limosipennella Dup.....Elm case bearer
Coleophora malivorella Riley.....Pistol case bearer
Colopha ulmicola Fitch.....Elm cockscomb gall
Coloradia pandora Blake.....Pandora moth
Columbicola columbae L.....Slender pigeon louse
Conotrachelus crataegi Walsh.....Quince curculio
Conotrachelus nenuphar Hbst.....Plum curculio
Contarinia johnsoni Sling.....Grape blossom midge
Contarinia pyrivora Riley.....Pear midge
Contarinia sorghicolla Coq.....Sorghum midge
Contarinia tritici Kby.....Wheat midge
Coptodisca splendoriferella Clem.....Resplendent shield bearer
Corimelaena pulicaria Germ.....Negrobug
Cordyalis cornuta L.....Dobson fly; Hellgramite

Cosmopolites sordidus Germ.....Banana root borer
Cotinis nitida L.....Green June beetle
Crambus caliginosellus Clem.....Corn root webworm
Crambus hortuellus Hbn.....Cranberry girdler
Crambus vulgivagellus Clem.....Vagabond crambus
Craponius inaequalis Say.....Grape curculio
Cremastobombycia lantanella Busck.....Lantana leaf miner
Cressonia juglandis S. & A.....Walnut sphinx
Crioceris asparagi L.....Asparagus beetle
Crioceris duodecimpunctata L.....Spotted asparagus beetle
Cryptococcus fagi Baer.....Beech scale
Cryptothrips floridensis Watson.....Camphor thrips
Ctenocephalides canis Curt.....Dog flea
Ctenocephalides felis Bouche.....Cat flea
Curculio caryae Horn.....Pecan weevil
Curculio proboscideus Fab.....Large chestnut weevil
Curculio rectus Say.....Chestnut weevil
Cylas formicarius Fab.....Sweetpotato weevil
Cyllene robiniae Forst.....Locust borer
Cynthia atlanta L.....Red admiral
Cynthia cardui L.....Painted lady
Cynthia virginiensis Drury.....Painted beauty

Dacus oleae Rossi.....Olive fruit fly
Danaus menippe Fab.....Monarch butterfly
Dasyneura leguminicola Lint.....Clover seed midge
Dasyneura rhodophaga Coq.....Rose midge
Dasyneura trifolii Loew.....Clover leaf midge
Datana integerrima G. & R.....Walnut caterpillar
Datana ministra Drury.....Yellow-necked caterpillar
Demodex bovis Stiles.....Cattle follicle mite
Demodex canis Leydig.....Dog follicle mite
Demodex canis ovis Raill.....Sheep follicle mite
Demodex caprae Raill.....Goat follicle mite
Demodex cati Megn.....Cat follicle mite
Demodex equi Raill.....Horse follicle mite
Demodex phylloides Csokor.....Hog follicle mite
Dendroctonus approximatus Dietz.....Colorado pine beetle
Dendroctonus arizonicus Hopk.....Arizona pine beetle
Dendroctonus barberi Hopk.....Southwestern pine beetle
Dendroctonus borealis Hopk.....Alaska spruce beetle
Dendroctonus brevicomis Lec.....Western pine beetle
Dendroctonus convexifrons Hopk.....Round-headed pine beetle
Dendroctonus engelmanni Hopk.....Engelmann-spruce beetle
Dendroctonus frontalis Zimm.....Southern pine beetle
Dendroctonus jeffreyi Hopk.....Jeffrey-pine beetle
Dendroctonus mexicanus Hopk.....Smaller Mexican pine beetle
Dendroctonus micans Kug.....European spruce beetle
Dendroctonus monticolae Hopk.....Mountain pine beetle

Dendroctonus murrayanae Hopk.....Lodgepole-pine beetle
Dendroctonus obesus Mann.....Sitka-spruce beetle
Dendroctonus parallelocollis Chap.....Larger Mexican pine beetle
Dendroctonus piceaperda Hopk.....Eastern spruce beetle
Dendroctonus ponderosae Hopk.....Black Hills beetle
Dendroctonus pseudotsugae Hopk.....Douglas-fir beetle
Dendroctonus punctatus Lec.....Allegheny spruce beetle
Dendroctonus rufipennis Kby.....Red-winged pine beetle
Dendroctonus simplex Lec.....Eastern larch beetle
Dendroctonus terebrans Oliv.....Black turpentine beetle
Dendroctonus valens Lec.....Red turpentine beetle
Depressaria heracliana DeG.....Parsnip webworm
Dermacentor albipictus Pack.....Winter tick
Dermacentor nigrolineatus Pack.....Brown winter tick
Dermacentor nitens Neum.....Tropical horse tick
Dermacentor occidentalis Neum.....Pacific Coast tick
Dermacentor variabilis Say.....American dog tick
Dermanyssus gallinae L.....Chicken mite
Dermestes lardarius L.....Larder beetle
Dermestes vulpinus Fab.....Hide beetle
Derocrepis erythropus Melsh.....Reg-legged flea beetle
Desmia funeralis Hbn.....Grape leaf folder
Diabrotica balteata Lec.....Banded cucumber beetle
Diabrotica duodecimpunctata Fab.....Spotted cucumber beetle
Diabrotica longicornis Say.....Corn root worm
Diabrotica soror Lec.....Western spotted cucumber beetle
Diabrotica trivittata Mann.....Western striped cucumber beetle
Diabrotica vittata Fab.....Striped cucumber beetle
Diacrisia virginica Fab.....Yellow woolly bear
Dialeurodes citri Ashm.....Citrus whitefly
Dialeurodes citrifolii Morg.....Cloudy-winged whitefly
Diaphania hyalinata L.....Melon worm
Diaphania nitidalis Stoll.....Pickle worm
Diapheromera femorata Say.....Walkingstick
Diarthronomyia hypogaea Loew.....Chrysanthemum gall midge
Diaspis bromeliae Kern.....Pineapple scale
Diaspis echinocacti Bouche.....Cactus scale
Diaspis piricola Del Guer.....Italian pear scale
Diatraea crambidoides Grote.....Southern corn stalk borer
Diatraea grandiosella Dyar.....Southwestern corn borer
Diatraea saccharalis Fab.....Sugarcane borer
Dichelonyx backi Kby.....Green rose chafer
Dichomeris ligulella Hbn.....Palmer worm
Dicyphus minimus Uhl.....Suckfly
Diocalandra taitensis Guer.....Tahitian cocoanut weevil
Diprion simile Htg.....Introduced pine sawfly
Dissosteira carolina L.....Carolina grasshopper
Drosophila ampelophila Loew.....Pomace fly
Dysdercus mimus Say.....Arizona cotton stainer

Dysdercus suturellus H. S.....Cotton stainer

Eacles imperialis Drury.....Imperial moth
Echidnophaga gallinacea Westw.....Sticktight flea
Elasmopalpus lignosellus Zell.....Lesser corn stalk borer
Eleodes opaca Say.....Plains false wireworm
Ellopia fiscellaria Guen.....Hemlock spanworm
Emphylina canadensis Kby.....Violet sawfly
Emphytus cinctipes Nort.....Curled rose sawfly
Empoasca fabae Harr.....Potato leafhopper
Empoasca maligna Walsh.....Apple leafhopper
Ennomos subsignarius Hbn.....Elm spanworm
Entomoscelis adonidis Pal.....Red turnip beetle
Eomenacanthus stramineus Nitz.....Chicken body louse
Ephestia cautella Walk.....Fig moth
Ephestia kuehniella Zell.....Mediterranean flour moth
Epicaerus imbricatus Say.....Imbricated snout beetle
Epicauta cinerea Forst.....Gray blister beetle
Epicauta maculata Say.....Spotted blister beetle
Epicauta marginata Fab.....Margined blister beetle
Epicauta pennsylvanica DeG.....Black blister beetle
Epicauta vittata Fab.....Striped blister beetle
Epicnaptera americana Harr.....Lappet moth
Epilachna borealis Fab.....Squash beetle
Epilachna corrupta Muls.....Mexican bean beetle
Epitrix cucumeris Harr.....Potato flea beetle
Epitrix fuscula Crotch.....Eggplant flea beetle
Epitrix parvula Fab.....Tobacco flea beetle
Epitrix subcrinita Lec.....Western potato flea beetle
Epochra canadensis Loew.....Currant fruit fly
Erannis tiliaria Harr.....Lime-tree looper
Eriocampoides limacina Retz.....Pear slug
Eriophyes fici Essig.....Fig mite
Eriophyes gossypii Bks.....Cotton blister mite
Eriophyes pyri Pgst.....Pear leaf blister mite
Eriophyes ribis Nal.....Currant bud mite
Eriosoma americana Riley.....Woolly elm aphid
Eriosoma lanigera Hausm.....Woolly apple aphid
Eriosoma pyricola Baker.....Woolly pear aphid
Erythraspides pygmaea Say.....Grape sawfly
Erythroneura comes Say.....Grape leafhopper
Erythroneura tricincta Fitch.....Three-banded leafhopper
Esthiopterum crassicorne Scop.....Slender duck louse
Estigmene acraea Drury.....Salt-marsh caterpillar
Etiella zinckenella Treit.....Lima bean pod borer
Euetheola rugiceps Lec.....Sugarcane beetle
Eulia juglandana Fern.....Hickory leaf roller
Eulia mariana Fern.....Gray-banded leaf roller
Eulia pinatubana Kearf.....Pine tube moth

Eulia velutinana Walk.....Red-banded leaf roller
Eumerus tuberculatus Rond.....Lesser bulb fly
Euphoria inda L.....Bumble flower beetle
Eurymus eurytheme Bdv.....Alfalfa caterpillar
Eurymus philodice Godt.....Clouded sulphur
Eurytoma orchidarum Westw.....Orchid fly
Eutettix tenellus Bak.....Beet leafhopper
Euxoa messoria Harr.....Dark-sided cutworm
Euxoa ochragaster Guen.....Red-backed cutworm
Euxoa scandens Riley.....White cutworm
Euxoa tessellata Harr.....Striped cutworm
Evergestis rimosalis Guen.....Cross-striped cabbage worm
Evoxysoma vitis Saund.....Grape seed chalcid
Exartema permundanum Clem.....Raspberry leaf roller

Fannia scalaris Fab.....Latrine fly
Felicola subrostrata Nitz.....Cat louse
Feltia annexa Treit.....Granulate cutworm
Feltia subgothica Haw.....Dingy cutworm
Fenusa dohrnii Tischbein.....European alder leaf miner
Fidia viticida Walsh.....Grape root worm
Forficula auricularia L.....European earwig
Formica fusca subsericea Say.....Silky ant
Frankliniella fusca Hinds.....Tobacco thrips
Frankliniella tritici Fitch.....Flower thrips

Galeruca externa Say.....Pepper grass beetle
Galerucella cavicollis Lec.....Cherry leaf beetle
Galerucella xanthomelaena Schr.....Elm leaf beetle
Galleria mellonella L.....Wax moth
Gargaphia solanii Heid.....Eggplant lacebug
Gastrophilus haemorrhoidalis L.....Nose botfly
Gastrophilus intestinalis DeG.....Horse botfly
Gastrophilus nasalis L.....Throat botfly
Gelastocoris oculatus Fab.....Toadbug
Glycobius speciosus Say.....Sugar-maple borer
Gnorimoschema glochinella Zell.....Eggplant leaf miner
Gnorimoschema operculella Zell.....Potato tuber worm
Goniocotes bidentatus Scop.....Small pigeon louse
Goniocotes gigas Tausch.....Large chicken louse
Goniocotes hologaster Nitz.....Fluff louse
Goniodes dissimilis Nitz.....Brown chicken louse
Goniodes meleagridis L.....Large turkey louse
Goniurus proteus L.....Bean leaf roller
Gossyparia spuria Mod.....European elm scale
Gracilaria cuculipennella Hbn.....Privet leaf miner
Gracilaria elotella Busck.....Apple bark miner
Gracilaria negundella Chamb.....Boxelder leaf roller
Gracilaria syringella Fab.....Lilac leaf miner

Grapholitha interstinctana Clem.....Clover head caterpillar
Grapholitha molesta Busck.....Oriental fruit moth
Grapholitha packardi Zell.....Cherry fruit worm
Graptolitha antennata Walk.....Green fruit worm
Gretchena bolliana Sling.....Pecan budmoth
Gryllotalpa hexadactyla Perty.....Northern mole cricket
Gryllus assimilis Fab.....Field cricket
Gryllus domesticus L.....House cricket
Gynaikothrips uzeli Zimm.....Cuban-laurel thrips

Haemaphysalis cinnabarina Koch.....Bird tick
Haemaphysalis leporis-palustris Pack.....Rabbit tick
Haematobia irritans L.....Horn fly
Haematopinus asini L.....Sucking horse louse
Haematopinus eurysternus Nitz.....Short-nosed cattle louse
Haematopinus suis L.....Hog louse
Haematosiphon inodorus Duges.....Poultry bug
Haemodipsus ventricosus Denny.....Rabbit louse
Halisidota caryae Harr.....Hickory tussock moth
Halisidota maculata Harr.....Spotted tussock moth
Halisidota tessellaris S. & A.....Pale tussock moth
Haltica bimarginata Say.....Alder flea beetle
Haltica chalybea Ill.....Grape flea beetle
Haltica ignita Auct.....Strawberry flea beetle
Haltica torquata Lec.....Blueberry flea beetle
Halticus citri Ashm.....Garden flea hopper
Hamadryas antiopa L.....Mourning-cloak butterfly
Harmolita grandis Riley.....Wheat straw worm
Harmolita tritici Fitch.....Wheat joint worm
Harmologa fumiferana Clem.....Spruce budworm
Harrisina americana Guer.....Grape leaf skeletonizer
Harrisina brillians B. & McD.....Western grape skeletonizer
Heliothis obsoleta Fab.....{Boll worm / Corn ear worm}
Heliothis virescens Fab.....Tobacco budworm
Heliothrips fasciatus Perg.....Bean thrips
Heliothrips haemorrhoidalis Bouche.....Greenhouse thrips
Hellula undalis Fab.....Cabbage webworm
Hemerocampa leucostigma S. & A.....White-marked tussock moth
Hemerocampa vetusta Bdv.....Western tussock moth
Hemerophila pariana Clerck.....Apple and thorn skeletonizer
Hemichionaspis aspidistrae Sign.....Fern scale
Hemileuca maia Drury.....Buck moth
Hemileuca oliviae Ckll.....Range caterpillar
Herse cingulata Fab.....Sweetpotato hornworm
Heterocampa guttivitta Walk.....Saddled prominent
Hippelates spp.....Eye gnats
Hippodamia convergens Guer.....Convergent ladybeetle
Horistonotus uhlerii Horn.....Sand wireworm

Howardia biclavis Comst.....Mining scale
Hyalopterus arundinis Fab.....Mealy plum aphid
Hydroecia micacea Esp.....Potato stem borer
Hylastinus obscurus Marsham.....Clover root borer
Hylemyia antiqua Meig.....Onion maggot
Hylemyia brassicae Bouche.....Cabbage maggot
Hylemyia cilicrura Rond.....Seed corn maggot
Hylemyia rubivora Coq.....Raspberry cane maggot
Hylemyia trichodactyla Rond.....Potato maggot
Hymenia fascialis Cram.....Hawaiian beet webworm
Hymenia perspectalis Hbn.....Spotted beet webworm
Hypena humuli Harr.....Hop looper
Hypera nigrirostris Fab.....Lesser clover leaf weevil
Hypera postica Gyll.....Alfalfa weevil
Hypera punctata Fab.....Clover leaf weevil
Hyphantria cunea Drury.....Fall webworm
Hypoderma bovis DeG.....Northern cattle grub
Hypoderma lineatum DeVill.....Common cattle grub
Hyponomeuta malinellus Zell.....Ermine moth
Hypothenemus hispidulus Lec.....Apple twig beetle
Hypsopygia costalis Fab.....Clover hay worm
Hysteroneura setariae Thos.....Rusty plum aphid

Icerya purchasi Mask.....Cottony-cushion scale
Illinoia pisi Kalt.....Pea aphid
Illinoia solanifolii Ashm.....Potato aphid
Iridomyrmex humilis Mayr.....Argentine ant
Ischnaspis longirostris Sign.....Black thread scale
Isia isabella S. & A.....Banded woolly bear
Itame ribearia Fitch.....Currant spanworm
Ithycerus noveboracensis Forst.....New York weevil
Itonida catalpae Comst.....Catalpa midge
Ixodes ricinus L.....Castor bean tick

Janus integer Nort.....Currant stem girdler
Jonthonota nigripes Oliv.....Black-legged tortoise beetle

Kaliosysphinga ulmi Sund.....Elm leaf miner

Laemophloeus minutus Oliv.....Flat grain beetle
Languria mozardi Latr.....Clover stem borer
Laphygma exigua Hbn.....Beet armyworm
Laphygma frugiperda S. & A.....Fall armyworm
Lasioderma serricorne Fab.....Cigarette beetle
Lasius niger americana Emery.....Cornfield ant
Laspeyresia caryana Fitch.....Hickory shuck worm
Laspeyresia nigricana Steph.....Pea moth
Laspeyresia prunivora Walsh.....Lesser apple worm
Lecanium cerasorum Ckll.....Calico scale

Lecanium corni Bouche.....European fruit lecanium
Lecanium nigrofasciatum Per .....Terrapin scale
Lecanium persicae Fab.....European peach scale
Lecanium prunastri Fonsc.....Globose scale
Lema trilineata Oliv.....Three-lined potato beetle
Lepidosaphes beckii Newm.....Purple scale
Lepidosaphes gloveri Pack.....Glover's scale
Lepidosaphes ulmi L.....Oyster-shell scale
Lepisma saccharina L.....Silverfish
Leptinotarsa decemlineata Say.....Colorado potato beetle
Leptinotarsa juncta Germ.....False potato beetle
Leptocoris trivittatus Say.....Boxelder bug
Leptoglossus phyllopus L.....Leaf-footed bug
Lethocerus americanus Leidy.....Giant water bug
Ligyrus gibbosus DeG.....Carrot beetle
Lipeurus heterographus Nitz.....Chicken head louse
Liponyssus bacoti Hirst.....Tropical rat mite
Lissorhoptrus simplex Say.....Rice water weevil
Listroderes obliquus Gyll.....Vegetable weevil
Lixus concavus Say.....Rhubarb curculio
Loxostege similalis Guen.....Garden webworm
Loxostege sticticalis L.....Beet webworm
Lucanus elaphus Fab.....Giant stag beetle
Ludius aereipennis Kby.....Prairie grain wireworm
Ludius suckleyi Lec.....Puget Sound wireworm
Luperodes brunneus Crotch.....Corn silk beetle
Lycophotia margaritosa saucia Hbn.....Variegated cutworm
Lygaeonematus erichsoni Htg.....Larch sawfly
Lygidea mendax Reut.....Apple redbug
Lygus communis Knight.....Pear plant bug
Lygus pratensis L.....Tarnished plant bug
Lytta nuttalli Say.....Nuttall's blister beetle
Lytta vesicatoria L.....Spanish fly

Macrobasis unicolor Kby.....Ash-gray blister beetle
Macrodactylus subspinosus Fab.....Rose chafer
Macronoctua onusta Grote.....Iris borer
Macrosiphoniella sanborni Gill.....Chrysanthemum aphid
Macrosiphum granarium Kby.....English grain aphid
Macrosiphum rosae L.....Rose aphid
Macrosiphum rudbeckiae Fitch.....Goldenglow aphid
Magicicada (Tibicina) septendecim L.....Periodical cicada
Malacosoma americana Fab.....Eastern ten caterpillar
Malacosoma californicus Pack.....California tent caterpillar
Malacosoma disstria Hbn.....Forest tent caterpillar
Malacosoma pluvialis Dyar.....Western tent caterpillar
Mamestra picta Harr.....Zebra caterpillar
Mancasellus brachyurus Harger.....Watercress sowbug
Marmara pomonella Busck.....Apple fruit miner

Melanoplus bivittatus Say.....Two-striped grasshopper
Melanoplus devastator Scudd.....Devastating grasshopper
Melanoplus differentialis Thos.....Differential grasshopper
Melanoplus femur-rubrum DeG.....Red-legged grasshopper
Melanoplus spretus Uhl.....Rocky Mountain grasshopper
Melanotus oregonensis Lec.....Oregon wireworm
Melittia satyriniformis Hbn.....Squash borer
Melophagus ovinus L.....Sheep tick
Merodon equestris Fab.....Narcissus bulb fly
Meromyza americana Fitch.....Wheat stem maggot
Metamasius hemipterus L.....West Indian cane weevil
Metamasius ritchei Mar.....Pineapple weevil
Metamasius sericeus Oliv.....Silky cane weevil
Metriona bicolor Fab.....Golden tortoise beetle
Microcentrum retinerve Burm.....Angular-winged katydid
Micronematus californicus Marlatt.....California pear slug
Mindarus abietinus Koch.....Balsam twig aphid
Mineola indigenella Zell.....Leaf crumpler
Mineola juglandis LeB.....{Pecan case bearer / Walnut case bearer}
Mineola vaccinii Riley.....Cranberry fruit worm
Miris dolabratus L.....Meadow plant bug
Monarthropalpus buxi Labou.....Boxwood leaf miner
Monochamus titillator Fab.....Southern pine sawyer
Monomorium minimum Buckl.....Little black ant
Monomorium pharaonis L.....Pharoah's ant
Monophadnoides rubi Harr.....Raspberry sawfly
Monoxia puncticollis Say.....Beet leaf beetle
Murgantia histrionica Hahn .....Harlequin bug
Musca domestica L.....House fly
Musca vicina Macq.....Oriental house fly
Myelois venipars Dyar.....Navel orange worm
Myzocallis fumipennellus Fitch.....Black pecan aphid
Myzocallis kahawaluokalani Kirk.....Crepe myrtle aphid
Myzus cerasi Fab.....Black cherry aphid
Myzus fragaefolii Ckll.....Strawberry aphid
Myzus houghtonensis Troop.....Gooseberry witch-broom aphid
Myzus persicae Sulz.....Green peach aphid
Myzus ribis L.....Currant aphid

Napomyza chrysanthemi Kowarz.....Chrysanthemum leaf miner
Necrobia ruficollis Fab.....Red-shouldered ham beetle
Necrobia rufipes DeG.....Red-legged ham beetle
Neleucania albilinea Hbn.....Wheat head armyworm
Neodiprion abietis Harr.....Spruce sawfly
Neodiprion lecontei Fitch.....Red-headed pine sawfly
Neolecanium cornuparvum Thro.....Magnolia scale
Neophasia menapia Feld.....Pine butterfly
Neotoxoptera violae Perg.....Violet aphid

Nephelodes emmedonia Cram.....Bronzed cutworm
Nephopteryx rubrizonella Rag.....Pear fruit borer
Nezara viridula L.....Southern green stink bug
Niptus hololeucus Fald.....Golden spider beetle
Nomius pygmaeus Dej.....Stink beetle
Notolophus antiqua L.....Rusty tussock moth
Nygmia phaeorrhoea Don.....Brown-tail moth
Nysius ericae Schill.....False chinch bug

Oberea bimaculata Oliv.....Raspberry cane borer
Oecanthus nigricornis Walk.....Black-horned tree cricket
Oecanthus nigricornis quadripunctatus Beut.....Four-spotted tree cricket
Oecanthus niveus DeG.....Snowy tree cricket
Oeciacus vicarius Horv.....Swallow bug
Oestris ovis L.....Sheep botfly
Olethreutes illepida Butl.....Koa seed worm
Olethreutes variegana Hbn.....Green budworm
Omiodes accepta Butl.....Sugarcane leaf roller
Omiodes blackburni Butl.....Cocoanut leaf roller
Omphisa anastomosalis Guen.....Sweetpotato vine borer
Oncideres cingulatus Say.....Twig girdler
Orchestes pallicornis Say.....Apple flea weevil
Orcus chalybeus Bdv.....Steel-blue ladybeetle
Ornithodoros megnini Duges.....Ear tick
Orthezia insignis Dougl.....Greenhouse orthezia
Oryzaephilus surinamensis L.....Saw-toothed grain beetle
Oscinella frit L.....Frit fly
Oxyptilus periscelidactylus Fitch.....Grape plume moth

Pachynematus ocreatus Harr.....Yellow-headed spruce sawfly
Pachypsylla celtidis-mamma Riley.....Hackberry nipple gall
Pachyzancla bipunctalis Fab.....Southern beet webworm
Paleacrita vernata Peck.....Spring canker worm
Papaipema nebris nitela Guen.....Stalk borer
Papaipema purpurifascia G. & R.....Columbine borer
Papilio glaucus form *turnus* L.....Tiger swallowtail
Papilio polyxenes Fab.....Parsley worm / Celery worm / Black swallowtail
Papilio thoas L.....Orange dog
Paraclemensia acerifoliella Fitch.....Maple leaf cutter
Paranthreme polistiformis Harr.....Grape root borer
Paratetranychus pilosus C. & F.....European red mite
Parlatoria blanchardi Targ.....Parlatoria date scale
Parlatoria pergandei Comst.....Chaff scale
Pectinophora gossypiella Saund.....Pink boll worm
Pediculus humanus corporis DeG.....Body louse
Pediculus humanus humanus L.....Head louse

Pegomyia hyoscyami Panz.....Spinach leaf miner
Pemphigus betae Doane.....Sugar beet root aphid
Peranabrus scabricollis Thos.....Coulee cricket
Periphyllus lyropictus Kess.....Norway maple aphid
Periphyllus negundinis Thos.....Boxelder aphid
Periplaneta americana L.....American cockroach
Periplaneta australasiae Fab.....Australian cockroach
Perkinsiella saccharicida Kirk.....Sugarcane leafhopper
Peronea minuta Rob.....Yellow-headed fireworm
Petrova comstockiana Fern.....Pitch twig moth
Phaedon aeruginosus Suffr.....Watercress leaf beetle
Phalacrus politus Melsh.....Smut beetle
Pheletes ectypus Say.....Eastern field wireworm
Philaenus lineatus L.....Lined spittle bug
Phlyctaenia rubigalis Guen.....Greenhouse leaf tier
Phlegethontius quinquemaculata Haw.....Tobacco worm
Phlegethontius sexta Johan.....Tomato worm
Phobetron pithecium S. & A.....Hag moth
Phoenicococcus marlatti Ckll.....Red date scale
Pholus achemon Drury.....Achemon sphinx
Phorodon humuli Schr.....Hop aphid
Phryganidia californica Pack.....California oak worm
Phthirius pubis L.....Crab louse
Phthorophloeus liminaris Harr.....Peach bark beetle
Phyll coptes oleivorus Ashm.....Citrus rust mite
Phyllotreta armoraciae Koch.....Horse-radish flea beetle
Phyllotreta pusilla Horn.....Western black flea beetle
Phyllotreta ramosa Crotch.....Western striped flea beetle
Phyllotreta vittata Fab.....Striped flea beetle
Phylloxera vitifoliae Fitch.....Grape phylloxera
Phytomyza aquilegiae Hardy.....Columbine leaf miner
Phytomyza delphiniae Frost.....Larkspur leaf miner
Phytomyza ilicis Curt.....Holly leaf miner
Phytophaga destructor Say.....Hessian fly
Pilocrocis tripunctata Fab.....Sweetpotato leaf roller
Pineus strobi Htg.....Pine bark aphid
Piophila casei L.....Cheese skipper
Pissodes deodarae Hopk.....Deodar weevil
Pissodes strobi Peck.....White-pine weevil
Plathypena scabra Fab.....Green clover worm
Platysamia cecropia L.....Cecropia moth
Platyptilia carduidactyla Riley.....Artichoke plume moth
Platyptilia pusillodactyla Walk.....Lantana plume moth
Plodia interpunctella Hbn.....Indian-meal moth
Plutella maculipennis Curt.....Diamond-back moth
Podisus maculiventris Say.....Spined soldier bug
Podosesia fraxini Lugger.....Ash borer
Podosesia syringae Harr.....Lilac borer
Poecilocapsus lineatus Fab.....Four-lined plant bug

Pogonomyrmex badius Latr.....Florida harvester ant
Pogonomyrmex barbatus Mayr.....Red harvester ant
Pogonomyrmex californicus Buckl.....California harvester ant
Polia legitima Grote.....Striped garden caterpillar
Polia renigera Steph.....Bristly cutworm
Pollenia rudis Fab.....Cluster fly
Polychrosis viteana Clem.....Grape berry moth
Polyphylla decemlineata Say.....Ten-lined June beetle
Pomphopoea sayi Lec.....Say's blister beetle
Popillia japonica Newm.....Japanese beetle
Porosagrotis orthogonia Morr.....Pale western cutworm
Porthetria dispar L.....Gypsy moth
Prenolepis longicornis Latr.....Crazy ant
Prionoxystus macmurtrei Guer.....Little carpenter worm
Prionoxystus robiniae Peck.....Carpenter worm
Prociphilus tessellatus Fitch.....Woolly alder aphid
Prodenia eridania Cram.....Southern armyworm
Prodenia ornithogalli Guen.....Yellow-striped armyworm
Proteoteras willingana Kearf.....Boxelder twig borer
Protopulvinaria pyriformis Ckll.....Pyriform scale
Psallus seriatus Reut.....Cotton flea hopper
Pseudaonidia duplex Ckll.....Camphor scale
Pseudococcus adonidum L.....Long-tailed mealybug
Pseudococcus brevipes Ckll.....Pineapple mealybug
Pseudococcus citri Risso.....Citrus mealybug
Pseudococcus gahani Green.....Citrophilus mealybug
Pseudococcus maritimus Ehrh.....Grape mealybug
Pseudococcus nipae Mask.....Cocoanut mealybug
Pseudolynchia maura Bigot.....Pigeon fly
Psila rosae Fab.....Carrot rust fly
Psoroptes communis Feurst.....Scab mite
Psoroptes ovis Her.....Sheep scab mite
Psorosina hammondi Riley.....Apple leaf skeletonizer
Psyllia buxi L.....Boxwood psyllid
Psyllia mali Schmid.....Apple sucker
Psyllia pyricola Foerst.....Pear psylla
Psylliodes punctulata Melsh.....Hop flea beetle
Pteronidea ribesii Scop.....Imported currant worm
Pteronidea ventralis Say.....Willow sawfly
Ptinus brunneus Dufts.....Brown spider beetle
Ptinus fur L.....White-marked spider beetle
Ptinus villiger Reit.....Hairy spider beetle
Pulex irritans L.....Human flea
Pulvinaria amygdali Ckll.....Cottony peach scale
Pulvinaria psidii Mask.....Green shield scale
Pulvinaria vitis L.....Cottony maple scale
Pycnoscelus surinamensis L.....Surinam roach
Pyralis farinalis L.....Meal moth
Pyrausta ainsliei Heinr.....Smartweed borer

Pyrausta nubilalis Hbn.....European corn borer

Rachela bruceata Hulst.....Bruce's spanworm
Recurvaria nanella Hbn.....Lesser budmoth
Reduvius personatus L.....Masked hunter
Rhabdopterus picipes Oliv.....Cranberry root worm
Rhagoletis cingulata Loew.....Cherry fruit fly / Cherry maggot
Rhagoletis fausta O. S.....Black cherry fruit fly
Rhagoletis juglandis Cress.....Walnut husk fly
Rhagoletis pomonella Walsh.....Apple maggot / Blueberry maggot
Rhipic phalus sanguinius Latr.....Brown dog tick
Rhizobius ventralis Er.....Black ladybeetle
Rhizoglyphus hyacinthi Bdv.....Bulb mite
Rhodites radicum O. S.....Rose root gall
Rhodites rosae L.....Mossy rose gall
Rhopalosiphum prunifoliae Fitch.....Apple grain aphid
Rhopalosiphum pseudobrassicae Davis.....Turnip aphid
Rhopobota naevana Hbn.....Black-headed fireworm
Rhyacionia buoliana Schiff.....European pine shoot moth
Rhynchites bicolor Fab.....Rose curculio
Rodolia cardinalis Muls.....Vedalia
Romalea microptera Beauv.....Eastern lubber grasshopper

Saissetia hemisphaerica Targ.....Hemispherical scale
Saissetia oleae Bern.....Black scale
Saperda calcarata Say.....Poplar borer
Saperda candida Fab.....Round-headed apple tree borer
Saperda tridentata Oliv.....Elm borer
Saperda vestita Say.....Linden borer
Sarcoptes scabiei DeG.....Itch mite
Scapteriscus vicinus Scudd.....Changa
Schistocerca americana Drury.....American grasshopper
Schizura concinna S. & A.....Red-humped caterpillar
Schizura unicornis S. & A.....Unicorn caterpillar
Scirtothrips citri Moult.....Orange thrips
Scobicia declivis Lec.....Lead cable borer
Scolytus quadrispinosus Say.....Hickory bark beetle
Scolytus rugulosus Ratz.....Shot-hole borer
Scotogramma trifolii Rott.....Clover cutworm
Scudderia furcata Bruner.....Fork-tailed bush katydid
Scutigera forceps Raf.....House centipede
Selenothrips rubrocinctus Giard.....Red-banded thrips
Septis arctica Bdv.....Yellow-headed cutworm
Sibine stimulea Clem.....Saddle-back caterpillar
Sidemia devastator Brace.....Glassy cutworm
Simulium meridionale Riley.....Turkey gnat
Sitodrepa panicea L.....Drug-store weevil

Sitona hispidula Fab.....Clover root curculio
Sitophilus granaria L.....Granary weevil
Sitophilus oryzae L.....Rice weevil
Sitotroga cerealella Oliv.....Angoumois grain moth
Sminthurus hortensis Fitch.....Garden springtail
Solenopsis geminata Fab.....Fire ant
Sphinx lineata Fab.....White-lined sphinx
Spilonota ocellana Schiff.....Eye-spotted budmoth
Spodoptera mauritia Bdv.....Nutgrass armyworm
Stagmomantis carolina Johan.....Carolina mantis
Stenopelmatus fuscus Hald.....Jerusalem cricket
Stephanitis rhododendri Horv.....Rhododendron lacebug
Sternochetus mangiferae Fab.....Mango weevil
Stilpnotia salicis L.....Satin moth
Stomoxys calcitrans L.....Stable fly
Straussia longipennis Weid.....Sunflower maggot
Strymon melinus Hbn.....Cotton square borer
Synanthedon tipuliformis L.....Currant borer
Syntomaspis druparum Boh.....Apple seed chalcid
Systena taeniata Say.....Banded flea beetle
Systena taeniata blanda Melsh.....Pale-striped flea beetle

Tabanus atratus Fab.....Black horse fly
Tabanus lineola Fab.....Striped horse fly
Tachycines asynamorus Adel.....Greenhouse stone cricket
Tachypterellus quadrigibbus Say.....Apple curculio
Taeniothrips inconsequens Uzel.....Pear thrips
Tapinoma sessile Say.....Odorous house ant
Tarsonemus pallidus Bks.....Cyclamen mite
Tegeticula alba Zell.....Yucca moth
Telea polyphemus Cram.....Polyphemus moth
Teleonemia lantanae Dist.....Lantana leaf bug
Tenebrio molitor L.....Yellow meal worm
Tenebrio obscurus Fab.....Dark meal worm
Tenebroides mauritanicus L.....Cadelle
Tenodera sinensis Sauss.....Chinese mantis
Tetraleurodes mori Quaint.....Mulberry whitefly
Tetramorium caespitum L.....Pavement ant
Tetranychus telarius L.....Common red spider
Tetraopes tetraophthalmus Forst.....Red milkweed beetle
Thamnotettix clitellarius Say.....Saddled leafhopper
Thermobia domestica Pack.....Fire brat
Thrips tabaci Lind.....Onion thrips
Thyridopteryx ephemeraeformis Haw.....Bagworm
Tinea granella L.....European grain moth
Tinea pellionella L.....Case-bearing clothes moth
Tineola biselliella Hum.....Webbing clothes moth
Tipula simplex Doane.....Range crane fly
Tischeria malifoliella Clem.....Apple leaf trumpet miner

Tortrix citrana Fern.....Orange tortrix
Toumeyella liriodendri Gmel.....Tulip tree scale
Toxoptera aurantiae Koch.....Black citrus aphid
Toxoptera graminum Rond.....Green bug
Toxotrypana curvicauda Gerst.....Papaya fruit fly
Trachykele blondeli Mars.....Western cedar borer
Tremex columba L.....Pigeon tremex
Trialeurodes floridensis Quaint.....Avocado whitefly
Trialeurodes packardii Morrill.....Strawberry whitefly
Trialeurodes vaporariorum Westw.....Greenhouse whitefly
Trialeurodes vittatus Quaint.....Grape whitefly
Triatoma sanguisuga Lec.....Blood-sucking conenose
Tribolium confusum Duv.....Confused flour beetle
Tribolium ferrugineum Fab.....Rust-red flour beetle
Tribolium spp.....Flour beetles
Trichobaris trinotata Say.....Potato stalk borer
Trichodectes equi L.....Horse biting louse
Trichophaga tapetzella L.....Carpet moth
Trinoton querquedulae L.....Large duck louse
Trioza diospyri Ashm.....Persimmon psylla
Troctes divinatoria Mull.....Booklouse
Trombicula irritans Riley.....Chigger
Tropaea luna L.....Luna moth
Tunga penetrans L.....Chigoe
Tychius picirostris Fab.....Clover head weevil
Tyloderma fragariae Riley.....Strawberry crown borer
Typhlocyba rosae L.....Rose leafhopper

Vespa crabro L.....Giant hornet
Vespula maculata L.....Bald-faced hornet

Winthemia quadripustulata Fab.....Red-tailed tachina
Wyeomyia smithii Coq.....Pitcher plant mosquito

Xenopsylla cheopis Rothsch.....Oriental rat flea
Xylocopa virginica Drury.....Carpenter bee
Xylotrechus aceris Fisher.....Gall-making maple borer

Zeuzera pyrina L.....Leopard moth
Zophodia grossulariae Riley.....Gooseberry fruit worm
Zygogramma exclamationis Fab.....Sunflower beetle

Scientific Notes

Altitude Records for *Diabrotica duodecimpunctata* (Fabricius) in Tennessee. On October 25, 1931, the author climbed Mt. Chapman in the Great Smoky Mountains National Park, and while resting after the strenuous climb saw beetles flying around from bush to bush in a southward direction. Upon examination the beetles were found to be *Diabrotica duodecimpunctata* (Fabricius). The peak has an altitude of 6430 feet and is located on the state line of Tennessee and North Carolina. Another interesting record for *D. duodecimpuntata* is on the top of a nineteen-story hotel building in Knoxville, Tennessee. The collection is recorded for September 17, 1931.

W. W. STANLEY, *Tennessee Agricultural Exp. Station*

Twelve-Spotted Asparagus Beetle in Iowa. *Crioceris duodecimpunctata* Linne, made its first appearance in America in the vicinity of Baltimore in 1881, some twenty years after the first discovery of its near relative, *C. asparagi* Linn., in this country. Since that time these two pests have spread rapidly, the former species seeming always to trail the latter and more common and injurious one into new territory. Although the common asparagus beetle made its appearance in Iowa around 1920 and has since devastated the asparagus crop in many parts of the state, a careful watch failed to disclose the twelve-spotted beetle until the past season, 1931, when the writer found it in several fields near Davenport. *C. duodecimpunctata* reached Illinois in 1925 and has not heretofore been recorded from west of the Mississippi river.

HALBERT M. HARRIS, *Dept. of Zoology and Entomology, Iowa State College, Ames, Iowa*

The Method of Ingress of Newly Hatched Larvae of the Throat Bot of Horses, *Gastrophilus nasalis* L.—It has been known that the eggs of this species hatch without friction or moisture, but little has been known as to how they enter the host. During the summer of 1931 large numbers of the eggs were clipped from the jaws of horses and permitted to hatch at room temperature in the laboratory. Newly hatched larvae were placed on the jaws of horses and closely observed. Almost invariably they migrated downward along the jaw toward the mouth, a few traveling a distance of about four inches and entering between the lips. A few put on the hair of the jaw crawled down to the skin and then toward the mouth, but none were observed to attempt penetration of the skin, even when they were moistened with saliva. Other larvae placed on an area where the hair had been clipped made no attempt to penetrate the skin.

R. W. WELLS, *Associate Entomologist, U. S. Bureau of Entomology*

CONFERENCE OF CONNECTICUT ENTOMOLOGISTS

The Eighth Conference of Entomologists working in Connecticut was held in the Assembly Room of the Agricultural Experiment Station, New Haven, on October 30, 1931. Dr. W. E. Britton was elected chairman, and 61 were present. The following program was carried out:

Greeting, Director William L. Slate, New Haven.
Shade Tree Defoliation. Dr. E. P. Felt, Stamford.
Entomological Features of the Season of 1931. Dr. W. E. Britton, New Haven.
Observations on the Chinese Mantid. S. W. Bromley, Stamford.
Collecting Diptera in Connecticut. Prof. Charles P. Alexander, Amherst, Mass.
The Gipsy Moth Problem. A. F. Burgess, Greenfield, Mass.
Motion pictures: Life Story of the Cecropia Moth. Prof. J. A. Manter, Storrs.
General Conditions on European Corn Borer and Japanese Beetle in the United States. L. H. Worthley, South Norwalk.
The Japanese Beetle in Connecticut. J. Peter Johnson, Shelton.
Some Notes on Lesser-Common Butterflies of Connecticut. Charles Rufus Harte, New Haven.
The Mexican Bean Beetle in Connecticut. Neely Turner, New Haven.
Notes on the Artificial Propagation of *Macrocentrus ancylivora*. Dr. Philip Garman, New Haven.
Cabbage Maggot Control. Dr. R. B. Friend, New Haven.

Mr. R. C. Botsford then showed a motion picture film of mosquito ditching operations and explained the progress of the work in Connecticut. Remarks were made by Harold L. Bailey, of Vermont, Professor A. E. Stene, of Rhode Island, and C. W. Collins, of Melrose Highlands, Mass.

The following were present: Professor Charles P. Alexander, Amherst, Mass.; John T. Ashworth, Danielson; Harold L. Bailey, Montpelier, Vt.; H. N. Bartley, South Norwalk; R. C. Botsford, New Haven; Professor A. I. Bourne, Amherst, Mass.; W. T. Brigham, New Haven; W. E. Britton, New Haven; S. W. Bromley, Stamford; Gladys Brooke, New Haven; A. F. Burgess, Greenfield, Mass.; T. M. Cannon, Hartford; C. W. Collins, Melrose Highlands, Mass.; F. B. Cook, Stratford; O. B. Cooke, Danielson; R. G. Cooper, Colebrook; S. S. Crossman, South Norwalk; A. DeCaprio, Hamden; R. M. DeCoursey, Storrs; Philip B. Dowden, Melrose Highlands, Mass.; E. P. Felt, Stamford; C. W. Frink, Willimantic; R. B. Friend, New Haven; Philip Garman, New Haven; Mr. and Mrs. R. D. Glasgow, Albany, N. Y.; James Hamilton, New Haven; C. R. Harte, New Haven; Mrs. J. E. Hobbs, Hamden; C. E. Hood, Melrose Highlands, Mass.; J. P. Johnson, Shelton; T. H. Jones, Melrose Highlands, Mass.; D. LaBelle, Ballouville; A. J. Lannon, Providence, R. I.; E. B. Lindquist, Guilford; J. A. Manter, Storrs; J. A. McEvoy, Putnam; Albert Morgan, Rocky Hill; W. J. Nalewaik, Storrs; G. H. Pallman, New Haven; T. J. Parr, New Haven; G. E. Pinckney, New Haven; G. H. Plumb, New Haven; J. C. Schread, New Haven; Betty Scoville, Hamden; W. L. Slate, New Haven; R. A. Spencer, Bloomfield; L. R. Stark, Greenfield, Mass.; A. E. Stene, Kingston, R. I. J. F. Townsend, New Haven; N. Turner, New Haven; B. H. Walden, New Haven; T. R. Ward, New London; A. J. Warren, New Haven; A. S. West, Jr., New Haven; W. D. Whitcomb, Waltham, Mass.; A. E. Wilkinson, Storrs; L. H. Worthley, South Norwalk, and M. P. Zappe, New Haven.

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

DECEMBER, 1931

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at $3.00 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptable illustrations. Photo-engravings may be obtained by authors at cost.

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ANNUAL SCIENTIFIC MEETINGS: 1931-1932, New Orleans; 1932-1933, Atlantic City.

Last summer a local and serious infestation of Japanese beetle was discovered in western Connecticut. A question very naturally arose as to the source of the infestation. An inquiry developed the fact that a quantity of sod was moved to this estate in the spring of 1930. The character of the infestation showed that it was distinctly local. It was possible to establish the identity of those responsible for the shipment, and as a result five individuals were fined $50 each and one $40 for this violation of the quarantine law. The case is suggestive as to the outcome of violations. There was apparently no suspicion of wrongdoing until more than a year after the offense was committed. The appearance of large numbers of beetles was evidence that there had been an illegal shipment. There are doubtless other violations of quarantine regulations. Not all of them may result in exposure as in this case. It is, however, a distinct possibility. The judge who passed the sentence held to the time-honored tradition that ignorance of the law was no excuse. It is obligatory upon those engaged in interstate transportation to know the laws controlling the shipment of various products. There is, as evidenced by the above, real danger, in the case of quarantine violations, that insects will supply the necessary clue to the conviction of offenders. It would be interesting to know how many others in this last class are apprehensive lest they be called to account for local infestations by destructive insects.

This is by no means the first time insect activities have been utilized to determine facts in relation to human activities. Horticulturists are continually checking the efficacy of their spraying operations by the

evidence furnished by insects. Unsatisfactory control means something wrong in the procedure. It may be the use of an ineffective spray, improper timing, or careless application. There is no gainsaying testimony of this character, and those attempting to control insects must keep this in mind. The quarantine violation noticed above is one of the striking illustrations of the value of insects as witnesses.

Reviews

Principales Plagas y Enfermedades de los Cultivos en la Republica Mexicana Incluyendo las Más Importantes de los Estados Unidos de Norteamérica. Work compiled by the Oficina Federal para la Defensa Agrícola, pages 1–375, 100 text figures, 8 colored plates, Tacubaya, D. F., Mexico, 1931.

This important work largely represents the labors of señor Don Fco, García Robledo, Chief of Defensa Agrícola, Dr. Alfonso Dampf, Chief of the Division of Investigation, and the personnel of the Department of Publications.

The rodents, diseases, and insects of economic importance and measures for their control are systematically considered clearly and concisely. This information is presented in such a manner that it can easily be comprehended by the intelligent agrarian. A chapter on the general ideas concerning insects and plant diseases is of further assistance to the farmer having no knowledge of these things.

The authors acknowledge the fact that considerable data, chiefly the mycological part, were taken from the "Extension Service Handbook on Agriculture and Home Economics," published by the United States Department of Agriculture. The information taken from the above work was not merely translated into Spanish, but was carefully adapted to suit conditions peculiar to Mexico. There are 36 original text figures and 8 colored plates. The accounts describing the combat of bats, birds, grasshoppers, and ants are of interest. The original particulars relative to the insects and diseases of the garbanza, lentil, avocado, cherimoya, guava, fig, mamey, and coconut in Mexico are of especial interest to the student of applied tropical and subtropical entomology. Even short accounts and the inclusion of the scientific names of some of the tropical insects of lesser importance are in themselves distinct contributions to this branch of economic entomology.

One of the most valuable features of this work is the extensive bibliography which covers pages 291 to 344 inclusive. This is the first bibliography concerning the subject of the protection of agriculture ever published in the Republic of Mexico. Dr. Alfonso Dampf has informed the writer that he spent seven years in the collection of some of the titles given in this work. He was materially assisted by the compilations made by señor Don Julio Riquelme Inda.

It is not amiss to add a few words about the Mexican organization which is responsible for this work. The name "Defensa Agrícola" may be misleading for we are apt to think of an organization whose scope of activities is similar to that of our Plant Quarantine and Control Administration. This is not the case. After the termination of the successful campaign against grasshopper outbreaks in 1926 by the "Junta Nacional Directora de la Campaña Contra la Langosta" the government foresaw the

need for a permanent organization for the investigation and control of plants and animals detrimental to agriculture. This led to the creation of the "Oficina Federal para la Defensa Agrícola" under the jurisdiction of the Secretary of Agriculture in December, 1926. Defensa Agrícola is comprised of four divisions: (1) Sanidad Agrícola, (2) Investigación, (3) Combate de Plagas, and (4) Técnico de Divulgación. The division of Sanidad Agrícola has to do with the quarantine and inspection phase of the work. The investigational division carries on studies embracing the fields of entomology, mycology, phytopathology, bacteriology, and chemistry. Under Combate de Plagas is found the organization of campaigns for the control of insects and plant diseases, carried on in cooperation with the farmers. The Departamento Técnico de Divulgación is concerned with the dissemination of information, publications, etc.

The personnel of Defensa Agrícola is to be commended for the production of such a thoroughly useful treatise which will be of especial value to agriculturists in other Latin-American countries as well as Mexico.

C. C. PLUMMER, *U. S. Bureau of Entomology, Cuernavaca, Morelos, Mexico*

Common Pests, How to Control Some of the Pests that Affect Man's Health, Happiness and Welfare by RENNIE W. DOANE, pages I–VIII, 1–384, 215 text illustrations. Charles C. Thomas, Springfield, Illinois; Baltimore, Maryland, 1931.

This is a manual or ready reference book for the farmer, stock man, gardener, the householder, and all others who may at times be more or less troubled with pests. The author has succeeded admirably in giving in a concise way the more essential information regarding the common pests that directly affect man, his domestic animals, his crops, his storehouses and his homes.

The scope of this small work is indicated by the chapters dealing with pests of man and domestic animals, including parasitic worms, insect control and some important pests of the orchard, garden, field and household, of grapes, of vegetable and truck crops, of field crops, of shade and forest trees and in lumber, of flower gardens, of greenhouses, of mills, storerooms and houses, of mammals as pests and birds as pests. The scope is distinctly broader than the ordinary entomology and the information in relation to these other forms will prove very acceptable to many entomologists as well as to those who are concerned with more practical affairs.

The author is an authority in his line and familiar with the latest advances in the various branches of science. He has produced a very readable, well illustrated work which should prove exceedingly useful to all having any interest, general or special, in the control of common pests.

E. P. FELT

Current News Notes

V. E. Romney, junior entomologist, Bureau of Entomology, has been transferred from State College, N. Mex., to Grand Junction, Colo.

P. K. Harrison, assistant entomologist, Bureau of Entomology, has been transferred from Fairfax, S. C., to Baton Rouge, La., effective October 1.

A. Peterson, Columbus, Ohio, went to Moorestown, N. J., August 28 and 29 to liberate tachinid parasites of the Mexican bean beetle in the New Jersey area.

Francis Munger, junior entomologist, Bureau of Entomology, reported for duty at the Takoma Park, Md., laboratory on July 13 to assist with the experimental work on the codling moth.

H. S. Cavitt has been appointed agent, Bureau of Entomology, at Alpine, Tex., and is to continue in charge of trap-plot experiments in connection with investigations of the pink bollworm.

Robert M. Jeffrey, Bureau of Entomology, completed his laboratory work at Berkeley, Calif., and left August 31 for the University of Minnesota, where he has accepted a research fellowship in plant nutrition.

Wm. C. McDuffie, field assistant, Bureau of Entomology, at Presidio, Tex., resigned on August 29 to accept a position as junior entomologist, Cereal and Forage Insect Investigations, at Salt Lake City, Utah.

Eric Pearson, of Cambridge, England, visited the Bureau of Entomology Cotton Insect Laboratory at Tucson, Ariz., on July 1, where he was shown the experimental work under way on the boll weevil.

David Brannon, a graduate of the State College of Washington, has accepted a two year Assistantship in the Department of Entomology at the University of Maryland, and is working for his Doctor's Degree.

Joseph Wilcox and W. W. Baker have been appointed as associate and junior entomologists, respectively, Bureau of Entomology and assigned to the raspberry fruitworm and the blackberry red mite investigations at the Puyallup, Wash., laboratory.

Carl Schmidt, formerly from the University of Minnesota and G. E. V. Herford, International Fellow in Entomology from London, visited on August 12, the Whittier, Calif. laboratory engaged in the study of insects affecting subtropical fruits and ornamental plants.

Professor C. R. Kellogg, Fukien Christian University, Foochow, China, is spending his third Sabbatical leave at the University of Maryland where he expects to complete work for his Doctor's Degree. Professor Kellogg is investigating the Chinese Honey Bee.

J. C. Evenden, Bureau of Entomology, Coeur d'Alene, Idaho, spent the first half of August in Yellowstone National Park, Teton National Forest, Cody Canyon and Tongue River Indian Reservation, where experimental spraying for bark beetles is being done.

During late August and September, Mr. G. H. Hammond and Mr. C. E. Petch, Entomological Branch, prepared 5,000 white grubs artificially parasitized with *Microphthalma michiganensis* for export to Australia for use in the control of similar insects in that Dominion.

During July and August the Entomological Branch laboratory staff, at Chatham, Ont., have been largely occupied with a severe outbreak of sod webworms, both in field and cultivated grasses. This was followed by an unexpected outbreak of green clover worm in beans.

The season has been one of great insect activity in Saskatchewan. The pale western cutworms, the red-backed cutworm and grasshoppers increased to outbreak proportions over a large area, necessitating extension work that has seriously interfered with the normal program of investigations.

Geo. I. Reeves, J. C. Hamlin, Ralph Bunn, Richard Newton, and Leleand J. Jones of the Salt Lake City, Utah, field laboratory, Bureau of Entomology, attended the entomologists' conference at Pingree Park, Colo., August 17 to 21, and discussed informally some recent developments of alfalfa weevil work.

Dr. D. T. Fullaway, who is in Japan collecting a dipterous parasite of the Japanese beetle and thrips parasites for introduction into Hawaii, made a number of visits to the Yokohama, Japan, laboratory and was much interested in the parasite work being done there.

Prof. W. E. Hoffman of Lingnan University, Canton, China, visited the following Bureau of Entomology laboratories during July: the Hipplelates Investigations Laboratory at Coachella, Calif., the Citrus Insects Laboratory at Whittier, Calif., and the Cotton Insects Laboratories, at Tucson, Ariz., and El Paso, Tex.

Mr. S. L. Crosthwait, a graduate of the University of Maryland, and for several years in the employ of the McCormick Company of Baltimore where he has been promoting pyrethrum products, has accepted an Assistantship and is studying for his Master's Degree at the University of Maryland.

Dr. R. D. Bird, Entomological Branch, has been appointed to the position of Entomologist at the Vernon, B. C. laboratory and reported for duty on July 17. Dr. Bird is undertaking a quantitative ecological study of insects in orchards of the Okanagan valley with special reference to cover crops and cultural methods.

During August James Zetek made the annual examination of the teredo test timbers for the Panama Canal. This is a cooperative project with the committee on Marine Piling Investigations of the N. R. C. Probably three of the ship-worms are new and, in addition, a new wood-boring phelad mollusk was found.

Mr. S. S. Crossman of the Plant Quarantine and Control Administration, U. S. D. A., who has been engaged for several years as First Assistant on the gipsy and browntail moth work has recently been transferred to a similar position on the European corn borer and Japanese Beetle project with headquarters at So. Norwalk, Conn.

In order to devote more time to entomological research, Dr. E. D. Ball has resigned as Dean and Director of the University of Arizona, College of Agriculture, and accepted a professorship in the Department of Zoology and Entomology of that Institution. Dr. Ball expects to take up active field work on the biology of the range grasshoppers.

Mr. Norman Criddle attended the annual meeting of the International Great Plains Crop Pest Committee at Boseman, Montana, on Aug. 7, being absent from the laboratory until August 20. En route, to and from Bozeman, Mr. Criddle spent much time surveying the grasshopper situation in Alberta, Saskatchewan and western Manitoba with a view to appraising the outbreak potentialities for 1932.

The European corn borer situation in New Brunswick and Nova Scotia, Canada, appears to be very encouraging this year, as scouting recently completed in those provinces indicates a decided decrease in the number of local infestations. In New Brunswick, only one small area was found infested, and, in Nova Scotia, infestations were found only at three points in Digby county.

Mr. J. H. Roberts, who received his Master's degree at the University of Maryland, June, 1931, spent the summer investigating the tick problem in relation to the possibility of spotted fever in Maryland. Following this investigation, Mr. Roberts spent several weeks at the National Museum studying Trichoptera. Mr. Roberts has accepted his former position as instructor in entomology at the Louisiana State University.

In addition to work in connection with the Canadian Insect Pest Survey, Mr. C. R. Twinn is conducting a study of blackflies and their breeding places in the Ottawa district, and, as time permits, is now going over collected material and also specimens in the National Collection, with a view to determining the species of Simuliidae that occur in Eastern Canada.

L. W. Noble, Bureau of Entomology, was transferred to the Presidio, Tex., laboratory early in August to conduct special tests on longevity, period of fertility, and oviposition under conditions as would be experienced by pink bollworm moths carried in the upper air currents, to determine the possibility of trap-plot infestation by moths after they have spent several days in the upper air.

Mr. R. P. Gorham, Entomological Branch, reports that following a wide-spread insect infestation of clover heads in New Brunswick, a survey indicated a very general and constant infestation of both the lesser clover weevil and what is probably clover midge throughout the province. Some time later the destructive occurrence of the black vine weevil required the distribution of a circular concerning its control.

Dr. Raymond L. Taylor, who last year was filling a temporary appointment a-instructor in entomology in the New York State College of Forestry, Syracuse Univers sity, has assumed his new duties as assistant professor of biology in the College of William and Mary and will give courses in botany and entomology. In the summers, Dr. Taylor is director of the Dorr Station of the Mount Desert Island Biological Laboratory, Bar Harbor, Me.

On August 15, a conference was held in El Paso concerning future work in the cultural-control experiments for the pink bollworm and boll weevil. Attending the conference were Professor R. W. Harned, Dr. F. L. Thomas, chief of the Division of Entomology Texas Experiment Station, W. L. Owen, jr., in charge of the Presidio, Tex., laboratory, D. A. Isler, assistant agricultural engineer, and A. J. Chapman of Presidio. Tentative plans were laid for the work during the ensuing year.

On July 3 an informal conference of entomologists was held at the Vincennes, Indiana, Bureau of Entomology laboratory, for the purpose of discussing the codling moth and the oriental fruit moth. Those in attendance were: Prof. J. J. Davis and G. E. Marshall, of Purdue University; W. P. Flint, M. D. Farrar, and S. C. Chandler,

of the Illinois State Natural History Survey; Dr. C. O. Eddy, of the University of Kentucky, and the permanent members of the bureau staff at Vincennes.

Mr. Arthur Kelsall, Entomological Branch, Annapolis Royal, N. S., reports that owing to the extreme severity of the apple scab in experimental orchards, quite marked results have been secured in the work in connection with the development of a good combined insecticide and fungicide. Promising results are being obtained by poison bait sprays against the apple maggot, but results with attractants have been mostly negative. Arsenical sprays have been tested in connection with the control of the blueberry maggot.

During the past two months Mr. R. G. Webber, Entomological Branch, of the Halifax inspection office has been stationed at Yarmouth, N. S., to carry on a special examination of plant products entering that port, particularly from the United States, and special attention was paid to the possibility of Japanese beetle introductions. It is of interest to record that a dead adult of this species was discovered in the radiator of a car. At Niagara Falls, Ontario, the Canadian inspectors located a dead Japanese beetle in a car, entering that port, containing household effects.

During August Mr. Arthur Gibson, Dominion Entomologist of Canada, visited the Branch laboratories in the various western provinces to interview the officers in charge and members of the staff, and to view the investigational work in progress. While in British Columbia, he attended a conference of entomologists, plant pathologists and horticulturists held at the Vernon laboratory in connection with the perennial canker situation in the Okanagan valley. As a result of this conference a five-year programme of research work dealing with woolly aphid and perennial canker was drawn up. Among other things, while in Western Canada, Mr. Gibson looked into the Winnipeg mosquito control campaign and visited Jasper National Park in connection with mosquito control.

Horticultural Inspection Notes

The Eastern Plant Board met at the American Museum of Natural History in New York City on November 18.

Mr. Orville L. Williams and Mr. H. E. Guthrie assisted Mr. Henry Ness in inspecting the nurseries of Iowa during the past summer.

Mr. Richard Faxon, in charge of the Plant Quarantine and Control Administration's activities in Porto Rico, visited Washington on October 20, for conference.

Mr. H. E. Guthrie, Assistant State Entomologist of Iowa, is assisting the Federal Plant Quarantine and Control Administration inspector in transit inspection at Council Bluffs, during October and November.

Mr. Melvin E. Wyant, of Mentor, Ohio, who for the past eleven years has been deputy orchard and nursery inspector for the State of Ohio, acted as nursery inspector in Kentucky during a part of July, August, September, and October.

A hearing to consider the extension of the Federal Japanese beetle quarantine to cover the States of Ohio and South Carolina was held on October 8 at Washington, D. C. A few days later announcement was made that the quarantined area would not be so extended.

The European corn borer was discovered during the summer and fall scouting season at two points in eastern Wisconsin, and over a considerable area in eastern and

southern New Jersey, according to an announcement of the Plant Quarantine and Control Administration.

Mr. Robert A. Rodgers, who was stationed at Nogales, Arizona, since January 16, 1922, was retired on September 30, 1931, on account of age. Prior to his assignment at Nogales, Mr. Rodgers was employed for several years in the Forest Service.

Mr. J. C. Dawson and Mr. Chas. Denny, deputy nursery inspectors of Missouri, have recently been appointed collaborators of the Plant Quarantine and Control Administration, and are assisting in transit inspection at Kansas City and St. Louis, respectively.

The Central Western Shippers Advisory Board, which at a previous meeting had asked the Federal government to issue a quarantine to prevent the further spread of the alfalfa weevil, decided in a session at Ogden, Utah, in June, to postpone for one year further effort to have such action taken.

The Federal satin moth quarantine regulations were revised effective December 1, adding 51 towns in Maine, Vermont, Massachusetts, and Connecticut, to the regulated areas, in providing for the reshipment from the regulated areas, under permit, of poplar and willow trees which have originated outside the regulated areas.

Mr. J. M. Corliss, in charge of the Federal transit inspection work at Chicago spent a day at Ames during October, going over the inspection work and methods in Iowa and conferring with the State Entomologist on cooperative transit inspection activities at Council Bluffs. On the same trip Mr. Corliss consulted Dr. K. C. Sullivan of Jefferson City, Mo., concerning similar work at St. Louis and Kansas City.

The following transfers have recently taken place on the Mexican Border: Mr. R. B. Haller from Roma to Brownsville; Mr. Geo. M. Jones from Zapata to Roma; Mr. G. A. Pfaffman from Laredo to Zapata; Mr. E. W. Ingle from Brownsville to Zapata; Mr. H. G. Frane from Hidalgo to Nogales; Mr. U. R. Kuhn from Laredo to Nogales; Mr. E. L. Talbert from Del Rio to Laredo; Mr. J. W. Stanton from Brownsville to Seattle, Washington.

According to the Phoenix Gazette of September 19, 1931, Mr. D. C. George, who has been connected with the Arizona Commission of Agriculture and Horticulture as plant pathologist in the past, succeeded Mr. J. H. O'Dell as State Entomologist, effective October 1. Mr. O'Dell had occupied that position since July 1, when he succeeded Dr. O. C. Bartlett. The present members of the Commission are Clinton Campbell, F. W. Creswell, and S. C. Sorenson.

Due to the recent finding of the Citrus White Fly (*Dialeurodes citri* Ashm.) in Santa Ana, Orange County, Calif., the Department of Agriculture of that State has extended the intrastate quarantine order (No. 11) relating to this pest to include the city of Santa Ana. Another change in this order was to remove two species of persimmons from the embargoed list and permit their movement from the infested area, if defoliated. This revision became effective on October 2, 1931.

Under recent changes in the nursery inspection regulations and plant quarantine requirements of Kansas, every outside nurseryman and dealer must file a printed copy of his current inspection certificate with the State Entomological Commission, at Topeka; gladiolus, dahlia, canna, iris, peony, rhubarb and asparagus roots are released from inspection when they are for retail sale in the community of the grower; and alfalfa meal is permitted entry from the weevil-infested States throughout the year under certain conditions.

Dr. S. B. Fracker of the Federal Department of Agriculture, in a radio broadcast over the National Broadcasting Company chain on October 22, 1931, discussed the "Spread of Quarantined Pests in 1931." In addition to describing the season's discoveries of the European corn borer and the Japanese beetle in new locations, he stated that the white pine blister rust was found for the first time to have crossed the southern and western boundaries of Pennsylvania into Maryland and the northern parts of Virginia, West Virginia, and Ohio. Infected pine trees were also found at one point in Iowa.

The California intrastate quarantine regulation (No. 4) pertaining to the weevil (*Brachyrhinus cribricollis*) was lifted, effective October 7, 1931, it having been determined that the weevil is "established in numerous localities in and throughout the State of California; that the presence of this insect can adequately be determined by careful and competent inspection; and that full authority for safely disposing of infested shipments is given in Section 2322*h* of the Political Code of the State of California." This regulation as originally issued applied to the movement of nursery stock, trees, or plants with soil from Los Angeles County to other parts of the State.

Mr. M. S. Yeomans, State Entomologist of Georgia, reports the successful eradication of an outbreak of sweet potato weevil in seaside morning glory plants on Cumberland Island, Ga. The infestation was found on April 20, 1930 on the ocean side of the island and an eradication campaign was instituted immediately. Chopping of the morning glories was the procedure followed and after three trips were made to the island in which all of the morning glories which could be found were chopped, only a very few vines remained with no old vines apparent. "It is very evident at this time," according to Mr. Yeomans, "that the morning glories and therefore the weevils have been eradicated on Cumberland Island by the method of killing the vines by chopping." A map showing the location of this island and of the infestation was sent to all States interested in the sweet potato weevil immediately upon this finding.

Under two orders issued by Mr. Lee A. Strong, Chief of the Plant Quarantine and Control Administration, on September 9 and October 28, respectively, the shipping season for Texas grapefruit, oranges and kumquats, produced in Cameron, Hidalgo and Willacy counties, has been increased for the current season to extend from Septembe- 9, 1931, to April 10, 1932, inclusive. This action is taken on the basis of evidence presented to the Department of Agriculture that such modification is desirable from the standpoint of Mexican fruit worm control and does not increase risk of propagating that insect. All clean-up and other requirements concerning the production and distribution of Texas citrus fruit remain unchanged. The discovery of any infestation of this insect within the regulated area will of necessity require immediate eradication and precautionary clean-up measures in any area which may be involved. The orders were issued as circulars PQCA-325 and PQCA-326.

Under the recent reorganization of plant quarantine work in Arizona, Mr. J. L. E. Lauderdale, District Entomologist at Yuma was appointed on August 1 Chief Quarantine Inspector of the State and assigned to the Yuma office. Mr. H. F. Tate, District Inspector at Tucson, was appointed Assistant Entomologist to succeed Mr. C. D. Lebert, and assigned to the Tucson office. Mr. W. T. Mendenhall, District Inspector at Safford was reappointed and will remain at that office. Mr. U. L. Russell, Chief Crop Pest Inspector, was appointed Quarantine Inspector and will remain at the Phoenix office. Mr. H. B. Skinner was reappointed Date Palm Inspector and will remain at the Phoenix office. Mr. Peter H. Benson and Mr. Glen Blair were

appointed Apiary Inspectors. Thirteen road inspection stations employing a personnel of fifty-two inspectors and one stenographer were closed on July 22, but those at Gila Bend and Salome were temporarily re-established the following week, with a personnel of nine inspectors, for the purpose of preventing the spread of the pink bollworm from the Salt River Valley to the Yuma and Parker Valleys.

Apiculture Notes

On August 18 W. J. Nolan and C. R. Kellogg held a conference with Prof. E. N. Cory, of the University of Maryland, in regard to Professor Kellogg's work on Chinese bees while in this country.

Arrangements have been made for a cooperative study of the trend and status of beekeeping in California, the work to be done by Voorhies and Galbraith, of the Giannini Foundation, and F. E. Todd, of the Pacific Coast Bee Culture Field Station. This work is to begin September 1.

Mr. Frank G. Rauchfuss, one of the outstanding commercial beekeepers of the Intermountain Region, died August 23 after only a short illness at the age of 35. His loss will be felt keenly, particularly by the Colorado Honey Producers Association of which he was a director and vice-president. Mr. Rauchfuss was a strong friend of the Laramie, Wyo., laboratory. He gave Dr. Eckert much valuable assistance in his work in the San Luis Valley of Colorado last summer.

On August 19 a Beekeepers' Auto Tour of beekeepers from York, Lancaster, and Cook Counties, Pa., visited the Somerset, Md., laboratory. There were 19 autos in the caravan and a total attendance of 95. The beekeepers arrived in time to have lunch on the laboratory grounds, and in the afternoon a program was given by the laboratory staff as follows: Dr. C. E. Burnside, Recent Developments in American Foulbrood Infection; Dr. C. L. Farrar, of the Massachusetts Agricultural College, Beekeeping in Massachusetts; M. H. Haydak of the University of Wisconsin, Beekeeping in Central Europe; Prof. C. R. Kellogg of Fukien Christian University, Foochow, China, Beekeeping in China; G. E. Marvin, The U. S. Honey Grades; and W. J. Nolan told of the work in the laboratory and presided over the meeting.

Notes on Medical Entomology

On August 5, W. G. Bruce, Bureau of Entomology, left Fargo, N. Dak., for Texas, where he will make further studies on cattle grubs and other insects, especially ticks, the stable fly, the horn fly, and lice, affecting man and animals.

Roy Melvin, assistant entomologist, Bureau of Entomology, has been added to the personnel of the Dallas, Tex., laboratory. Mr. Melvin received his bachelor's degree from Mississippi A. & M. in 1927, the degree of master of science from Iowa State College in 1928, and has recently finished the requirements for the degree of doctor philosophy, at Iowa State College. He is a member of Sigma Xi and Gamma Sigma Delta. He has been assigned to do research on fly sprays.

H. H. Stage, with members of the Mosquito Control and Elimination Committee of the Portland Chamber of Commerce, attended a meeting of the tax commissioners of Clark County, Wash. Request was made that they cooperate with Multnomah County, Oreg., on mosquito control for 1932. Mr. Stage was appointed chairman of a committee to formulate a program of work to be done this winter. He was also appointed chairman of a committee to cooperate with the Port of Portland toward a program of permanent control.

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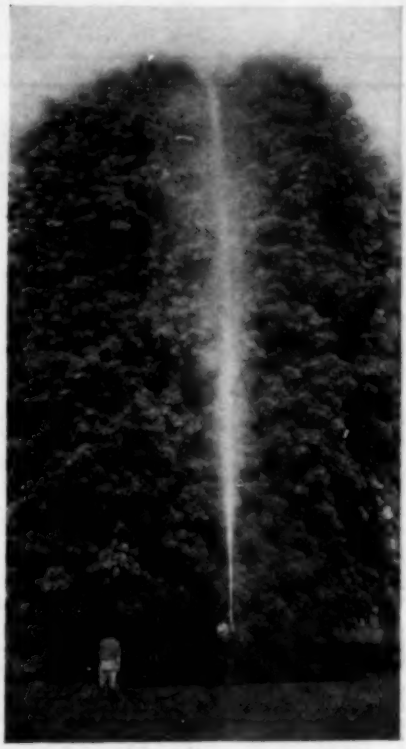

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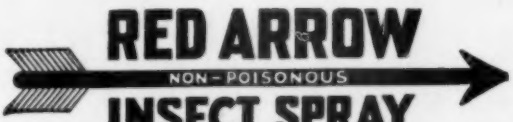

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